JOURNAL OF CRITICAL REVIEWS

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

Facial Identification System using Local Phase Quantization based on Deep Learning approach

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ABSTRACT;

Face recognition theories and techniques have attracted a lot of attention in latest generations. Video surveillance, criminal identification, building access management, and not having the autonomous vehicles are just a few of the actual applications that are gaining traction in the industry. Local, holistic, but hybrid approaches are really being developed, which provide a face image description utilizing only a few faces image features or the entire facial features. This latest survey main contribution is a study of certain well-known strategies for each strategy, as well as a taxonomy of their categories. A full comparison of various strategies is included in the study, which lists the benefits and drawbacks of their schemes in terms of robustness, accuracy, complexity, and discrimination. The database employed for facial recognition is one unique look mentioned in the paper. The most commonly utilized databases, including supervised and unsupervised learning databases, are reviewed. The much more fascinating techniques' numerical findings are discussed, along with the background of the experiments and difficulties they addressed. Finally, the study includes a thorough assessment on future developments in terms of facial recognition systems.

Keywords: face recognition systems, person identification, biometric systems, and survey

INTRODUCTION;

In smart cities, one goal of developing biometric applications such as facial recognition has lately become crucial. Furthermore, many scientists and engineers around the world have been working to develop increasingly robust and accurate algorithms and procedures for these systems and their use in everyday life. Personal data needs to be protected by all security mechanisms. The password is the most popular kind of recognition. Many systems are beginning to use many biometric features for recognizing tasks as technological advancement and security algorithms advance [1,2,3,4]. These biometric parameters allow people's identities to be determined based on physical or behavioral traits. They also have a number of advantages, such as the ability to detect the presence of a person in front of the sensor. There is no longer any need to remember several passwords or private codes. Many recognition systems biometric - based characteristics such as iris, fingerprints, voice, and face have been employed in recent times in this area.

To sum up, the contributions of this paper review are as follows:

- We first introduced face recognition as a biometric technique.
- We presented the state of the art of the existing face recognition techniques classified into three approaches: local, holistic, and hybrid.
- The surveyed approaches were summarized and compared under different conditions.
- We presented the most popular face databases used to test these approaches.
- We highlighted some new promising research directions.

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

1. Essential Steps of Face Recognition Systems

Face detection, feature extraction, and face recognition (shown in Figure 1) are the three basic steps in developing a strong face recognition system [2,3]. The face detection stage is used to detect and locate the system's human face image. The feature extraction stage is used to extract feature vectors for any human face that was discovered in the first step. Finally, the face recognition stage compares the retrieved features from the human face to all template facial images in order to determine the human face identification..

A. Face Detection

Face Detection: This stage determines whether or not the incoming image contains any human faces. Face detection might be hampered by fluctuations in lighting and facial expression. Pre-processing activities are carried out in order to enable the creation of a more powerful face recognition system easier. Viola–Jones detector histogram of oriented gradient (HOG) and principal component analysis (PCA) are two techniques used to detect and locate the human face picture. Face detection can also be utilized for video and picture classification, object detection, and region-of-interest detection [4], among other things.

B. Feature Extraction

The major purpose of this step is to extract the features of the face photos that were detected in the detection step. This stage displays a face with a "signature," which describes the prominent characteristics of the face image, such as the lips, nose, and eyes, as well as their geometric distribution. Each face has a unique structure, size, and form that allow it to be recognized. Several strategies use the size and distance to identify the face by extracting the shape of the lips, eyes, or nose. HOG, Eigen face, independent component analysis (ICA), linear discriminate analysis (LDA) , scale-invariant feature transform (SIFT) [5], gabor filter, local phase quantization (LPQ) , Haar wavelets, Fourier transforms , scale-invariant feature transform (SIFT) , scale-invariant feature transform (SIFT)

C. Face Recognition

This stage matches the backdrop features extracted during the feature extraction step to known faces recorded in a database. Face recognition are used for two different purposes: identification and verification. A test face is compared to a set of faces in the identification step to discover the most likely match. In order to determine the acceptance or rejection decision, a test face is compared to a known face in the database during the identification process. This task has been successfully addressed by correlation filters (CFs), convolution neural networks (CNNs), and k-nearest neighbor (K-NN).

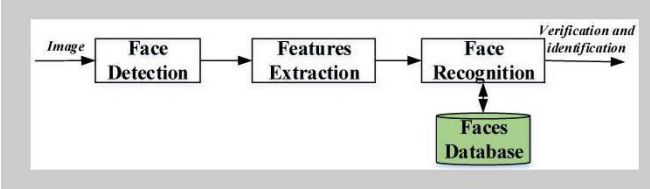

Fig.1: Classification of Face Recognition Systems

The face recognition system is not as efficient or trustworthy as other biometric systems such as eye, iris, or fingerprint recognition systems [6]. Moreover, despite all of the foregoing advantages, this biometric system has numerous limitations arising from numerous obstacles. Recognition has reached saturation in controlled contexts. Nonetheless, because of huge differences in lighting circumstances, facial expressions, age, dynamic background, and other factors in uncontrolled contexts, the topic

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

remains unresolved. We review the most advanced face recognition systems proposed in controlled and uncontrolled contexts utilizing various databases in this article study.

To recognize a human face in 2D or 3D photos, several techniques are used. Based on their detection and recognition methods, we shall group these systems into three ways in this review paper: (1) local, (2) holistic (subspace), and (3) hybrid approaches. The first method classifies people based on specific facial traits rather than the entire face. The second method uses the complete face as input data before projecting it onto a small subspace or in the correlation plane. The third method improves facial recognition accuracy by combining local and global characteristics.

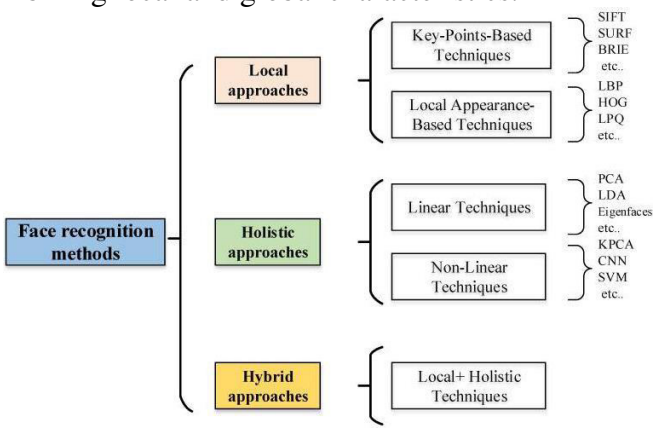

Fig 2: Local Approaches

Local approaches to face recognition only consider a few facial traits. They're more aware of facial expressions, occlusions, and posture. The basic goal of these approaches is to find distinguishing characteristics. These approaches can be split into two types in general: (1) To extract local features, local appearance-based approaches are applied, and the facial image is separated into small sections (patches). (2) In order to extract the features localized on these spots, key-point-based algorithms are utilized to detect the points of interest in the facial image.

2. Local Appearance-Based Techniques

It's a geometrical technique that's also known as a feature or analytic technique. The face image is represented in this scenario by a set of different vectors with small dimensions or small areas (patches). To create more information, local appearance-based techniques focus on crucial parts of the face such as the nose, lips, and eyes. It also considers the uniqueness of the face as a natural shape in order to identify and apply a smaller number of characteristics. Furthermore, these techniques use pixel orientations, histograms, geometric qualities, and correlation planes to express local features.

LBP (local binary pattern) and variants: LBP is a versatile texture extraction technology that may be used to any object. Face identification, facial expression recognition, texture segmentation, and texture classification are just a few of the applications where it excels. The LBP method separates the face picture into spatial arrays initially. Following that, a 33-pixel matrix (p1.....p8) is mapped over each array square. To generate the binary code, the pixel of this matrix is used as a threshold with the value of the centre pixel (p0) (i.e., use the intensity value of the centre pixel i(p0) as a reference for thresholding). If the value of a neighbour pixel is less than the value of the centre pixel, it is given a zero; otherwise, it is given a one.

LBP=$\sum p=182ps\ (i0-ip)$, with s(x)={10x≥0x<0,

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Where i0 and ip are the intensity value of the center pixel and neighborhood pixels, respectively. Illustrates the procedure of the LBP technique.

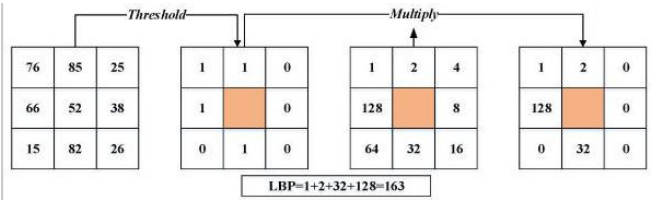

Fig 3: Holistic Approach

3. Linear Techniques

The most popular linear techniques used for face recognition systems are Eigen faces (principal component analysis; PCA) technique, Fisher faces (linear discriminative analysis; LDA) technique, and independent component analysis (ICA).

Eigen face and principal component analysis (PCA) Eigen faces are one of the popular methods of holistic approaches used to extract features points of the face image. This approach is based on the principal component analysis (PCA) technique. The principal components created by the PCA technique are used as Eigen faces or face templates. The PCA technique transforms a number of possibly correlated variables into a small number of incorrect variables called “principal components”. The purpose of PCA is to reduce the large dimensionality of the data space (observed variables) to the smaller intrinsic dimensionality of feature space (independent variables), which are needed to describe the data economically. Shows how the face can be represented by a small number of features. PCA calculates the Eigenvectors of the covariance matrix, and projects the original data onto a lower dimensional feature space, which are defined by Eigenvectors with large Eigen values. PCA has been used in face representation and recognition, where the Eigenvectors calculated are referred to as Eigen faces

Calculate the estimate covariance matrix to represent the scatter degree of all feature vectors related to the average vector. The covariance matrix Q is defined by the following:

$$Q=1N\sum i=1N(X\overline{\quad}-Xi)(X\overline{\quad}-Xi)T.$$

The Eigenvectors and corresponding Eigen-values are computed using

$$CV=\lambda V, \quad (V\epsilon Rn, V\neq 0),$$

Fig 4: Nonlinear Techniques

Kernel PCA (KPCA): is an improved method of PCA, which uses kernel method techniques. KPCA computes the Eigen faces or the Eigenvectors of the kernel matrix, while PCA computes the covariance

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

matrix. In addition, KPCA is a representation of the PCA technique on the high-dimensional feature space mapped by the associated kernel function. Three significant steps of the KPCA algorithm are used to calculate the function of the kernel matrix K of distribution consisting of n data point's xi∈Rd, after which the data points are mapped into a high-dimensional feature space F, as shown in Algorithm 2.

4. Hybrid Approach

The hybrid approaches are based on local and subspace features in order to use the benefits of both subspace and local techniques, which have the potential to offer better performance for face recognition systems.

Gabor wavelet and linear discriminate analysis (GW-LDA) Fathima et al. Proposed a hybrid approach combining Gabor wavelet and linear discriminate analysis (HGWLDA) for face recognition. The grayscale face image is approximated and reduced in dimension.

Over-complete LBP (OCLBP), LDA, and within class covariance normalization (WCCN): Barkan et al. proposed a new representation of face image based over-complete LBP (OCLBP).

Advanced correlation filters and Walsh LBP (WLBP): Juefei et al. implemented a single-sample periocular-based alignment-robust face recognition technique based on high-dimensional Walsh LBP (WLBP).

Multi-sub-region-based correlation filter bank (MS-CFB): Yan et al. offer a robust face recognition feature extractor called multi-sub-region-based correlation filter bank (MS-CFB).

PCA, SIFT features, and Fisher vectors: Based on the SIFT descriptor and Fisher vectors, Simonyan et al. [6] developed a unique approach for facial recognition software. Due to the high dimensionality of the Fisher vectors, the authors propose a discriminative dimensionality reduction.

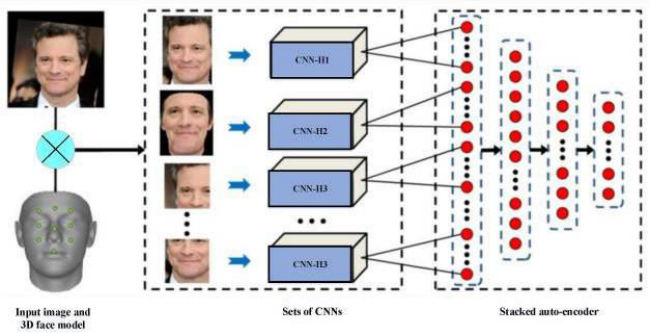

Fig 5: Hybrid Approach

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PCA, local Gabor binary pattern histogram sequence (LGBPHS), and GABOR wavelets: Cho et al. Proposed a computationally efficient hybrid face recognition system that employs both holistic and local features.

Authors and Affiliations

5. Summary of Hybrid Approaches

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

Summarizes the hybrid approaches that we presented in this section. Various techniques are introduced to improve the performance and the accuracy of recognition systems. The combination between the local approaches and the subspace approach provides robust recognition and reduction of dimensionality under different illumination conditions and facial expressions. Furthermore, these technologies are presented to be sensitive to noise, and invariant to translations and rotations.

6. Assessment of Face Recognition Approaches

In the last step of recognition, the face extracted from the background during the face detection step is compared with known faces stored in a specific database. To make the decision, several techniques of comparison are used. This section describes the most common techniques used to make the decision and comparison.

6.1. Measures of Similarity or Distances

Peak-to-correlation energy (PCE) or peak-to-side lobe ratio (PSR) The PCE was introduced in (8). Euclidean distance The Euclidean distance is one of the most basic measures used to compute the direct distance between two points in a plane. If we have two points P1 and P2.

The coordinates (x1, y1) and (x2, y2), respectively, the calculation of the Euclidean distance between them would be as follows:

$$dE(P1, P2)=(x2−x1)2+(y2−y1)2$$

6.2. Databases Used

LFW (Labeled Faces in the Wild) database was created in October 2007. It contains 13,333 images of 5749 subjects, with 1680 subjects with at least two images and the rest with a single image.

FERET (Face Recognition Technology) database was created in 15 sessions in a semi-controlled environment between August 1993 and July 1996. It contains 1564 sets of images, with a total of 14,126 images.

Pointing Head Pose Image Database (PHPID) is one of the most widely used for face recognition. It contains 2790 monocular face images of 15 persons with tilt angles from −90° to +90° and variations of pan. Every person has two series of 93 different poses (93 images). The face images were taken under different skin color and with or without glasses.

7. Discussion about Future Directions and Conclusions

In the past decade, the face recognition system has become one of the most important biometric authentication methods. Many techniques are used to develop many face recognition systems based on facial information. Generally, the existing techniques can be classified into three approaches, depending on the type of desired features.

- Local approaches: use features in which the face described partially. For example, some system could consist of extracting local features such as the eyes, mouth, and nose. The features' values are calculated from the lines or points that can be represented on the face image for the recognition step.

ISSN- 2394-5125 VOL 7, ISSUE 19, 2020

- Holistic approaches: use features that globally describe the complete face as a model, including the background (although it is desirable to occupy the smallest possible surface).

- Hybrid approaches: combine local and holistic approaches.

The main purpose of techniques such as HOG, LBP, Gabor filters, BRIEF, SURF, and SIFT is to discover distinctive features, which can be divided into two parts: (1) local appearance-based techniques, which are used to extract local features when the face image is divided into small regions (including HOG, LBP, Gabor filters, and correlation filters); and (2) key-points-based techniques, which are used to detect the points of interest in the face image, after which features' extraction is localized based on these points, including BRIEF, SURF, and SIFT. In the context of face recognition, local techniques only treat certain facial features, which make them very sensitive to facial expressions and occlusions
The relative robustness is the main advantage of these feature-based local techniques. Additionally, they take into account the peculiarity of the face as a natural form to recognize a reduced number of parameters. Another advantage is that they have a high compaction capacity and a high comparison speed. The main disadvantages of these methods are the difficulty of automating the detection of facial features and the fact that the person responsible for the implementation of these systems must make an arbitrary decision on really important points.
. Unlike the local approaches, holistic approaches are other methods used for face recognition, which treat the whole face image and do not require extracting face regions or features points (eyes, mouth, noses, and so on). The main function of these approaches is to represent the face image with a matrix of pixels. This matrix is often converted into feature vectors to facilitate their treatment. After that, the feature vectors are applied in a low-dimensional space. In fact, subspace techniques are sensitive to different variations (facial expressions, illumination, and different poses), which make them easy to implement. Many subspace techniques are implemented to represent faces such as Eigenface, Eigenfisher, PCA, and LDA, which can be divided into two categories: linear and non-linear techniques. The main advantage of holistic approaches is that they do not destroy image information by focusing only on regions or points of interest.

8. CONCLUSION;

Face recognition system is a popular study task in the field of image processing and computer vision, owing to its potentially enormous application as well as its theoretical value. This system is widely deployed in many real-world applications such as security, surveillance, homeland security, access control, image search, human-machine, and entertainment. However, these applications pose different challenges such as lighting conditions and facial expressions. This paper highlights the recent research on the 2D or 3D face recognition system, focusing mainly on approaches based on local, holistic (subspace), and hybrid features. A comparative study between these approaches in terms of processing time, complexity, discrimination, and robustness was carried out. We can conclude that local feature techniques are the best choice concerning discrimination, rotation, translation, complexity, and accuracy. We hope that this survey paper will further encourage researchers in this field to participate and pay more attention to the use of local techniques for face recognition systems.

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