A Review of Person Recognition Based on Face Model

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Abstract: Face recognition has become an attractive field in computer-based application development in the last few decades. This is because of the wide range of areas in which it is used. In addition, because of the wide variations of faces, face recognition from database images, real data, capture images, and sensor images are a challenging problem and limitation. Image processing, pattern recognition, and computer vision are relevant subjects to the face recognition field. The innovation of new approaches of face authentication technologies is a continuous subject to building much stronger face recognition algorithms. In this work, to identify a face, three major strategies for feature extractions are discussed. Appearance-based, Model-based methods and hybrid methods as feature extractions techniques are discussed too. There is also a review of major person recognition research. The characteristics of good face authentication applications, Classification, Distance measurements, and face databases are discussed while the final suggested methods are presented. This research has six sections ordered as follows: Section one is the introduction. Section two is dedicated to applications related to face recognition. In section three, face recognition techniques are presented by details. Then, classification types are illustrated in section four. In section five, standard face databases are presented. Finally, in section six, the conclusion is presented followed by the list of references.

Keywords: Appearance-Based Model, Model-Based, Hybrid Based, Classification, Distance Measurements, Face Databases, Face Recognition

1. Introduction

Over the most recent couple of decades, facial recognition has been considered the standout among the most imperative applications compared to other biometric-based systems. The facial recognition process can be stated as follows: given a database consisting of many face pictures of known people, one inputs a face picture, and the process aims to verify or determine the identity of the person in the input image (Jafri & Arabnia, 2009). Biometric-based strategies have been developed as the most capable alternative for perceiving people of late, rather than confirming individuals and conceding them access to physical and virtual spaces based on passwords, PINs, keen cards, plastic cards, tokens, keys etc.,. These strategies analyze a person's physiological as well as behavioral attributes with a specific end goal to decide and/or ascertain his/her identity. Passwords and PINs are difficult to recollect and can be stolen or speculated; cards, tokens, keys and so forth can be lost, overlooked, purloined or copied; attractive cards can wind up noticeably tainted and garbled. However, the natural biology of people cannot be lost, overlooked, stolen, or manufactured. Some examples include physiological characteristics of a person, such as facial images, fingerprints, finger geometry, hand geometry, hand veins, palm, iris, retina, ear and voice and behavioral traits, such as gait,

signature, and keystroke dynamics, which are used in biometric strategies for personal verification or identification especially for security systems. Security applications have witnessed a huge development during the last few decades, which is a natural result of the technological revolution in all fields, especially in smart environment sectors. Face features in face recognition for individual identification are considered a major method of the biometric area. Nowadays, if a person appears in a video or digital image, they can be automatically identified by Facial Recognition System (FRS), which is a significant technique to enhance security problems (Zafaruddin & Fadewar, 2014). Recently, many researchers focused on face recognition techniques. The human face in a person recognition application is a unique and valuable trait. It seems to offer a few points of interest over other biometric. Many methods are illustrated here, but almost all other innovations require some deliberate actions by the client, i.e., the client needs to put his/her hand on a hand-rest for fingerprinting or hand geometry location and needs to remain in a settled position before a camera for iris or retina recognition. Nevertheless, it should be possible to use face recognition inactively, with no express activity or cooperation with respect to the member, since face pictures are gained from a distance by a camera. In contrast, low resolution, light, a variation in the person's poses, and illumination variation are some drawbacks of facial recognition. Sometimes a person's face may not be visible. Therefore, face recognition systems provide researchers the opportunity to invent a new method to solve these drawbacks, which will enhance security and help in discovering new optimization techniques for face recognition (Jafri & Arabnia, 2009) (Setyadi & Tri Harsono, 2015). The idea behind the face recognition system is to determine the known and unknown faces, so a face recognition system uses pattern recognition. Because of the challenges of person recognition, such as: faces are highly dynamic and pose, and scantiness in this area of pattern recognition, artificial intelligence and computer vision suggest many solutions to enhance the accuracy and robustness of recognition (Li & Jain, 2011).

2. Application of Face Recognition

Nowadays, biometric-based security applications have been dramatically increased, especially in the area of face recognition. Thus, face recognition applications are a powerful way to accurately and robustly provide of personal security such as with a smart home, smart card, law enforcement, surveillance, or for entertainment (Li & Jain, 2011) (Parveeni & Thuraisingham, 2006). Table 1 illustrates the process that face recognition goes through.

Table 1: The methods that face recognition covers

Fields	Scenarios of applications (Examples)
Security	Terrorist alert, secure flight boarding systems, stadium audience scanning, computer security.
Face ID	Driver licenses, entitlement programs, immigration, national ID.
Face Indexing	Labeling faces in the video.
Access Control	Border-crossing control, facility access, vehicle access, smart kiosk, and ATM, computer access, and computer program access.
Multimedia Environment	Face-based search, face-based video segmentation summarization, and event detection.
Smart Cards Application	Stored value security, and user authentication.
Human-Computer Interaction (HCI)	Interactive gaming and proactive computing.
Face Databases	Face indexing and retrieval, automatic face labeling and face classification.
Surveillance	Advanced video surveillance, nuclear plant surveillance, park surveillance, and neighborhood watch, power grid surveillance as well as CCTV Control and portal control.

2.1 Smart Home

Recently, the design of smart home or cities has become one of the things that many researchers have focused on. Some examples include designing a smart house for people with special needs, patients, or the public, to help them meet their needs in the easiest and fastest way. With the development of these devices, there is a possibility of connecting with the outside world and using home appliances that remotely use modern technology. For example, using facial recognition techniques or speech or gate behaviors without physical connection with the person, and here lies the importance of using facial recognition techniques to design smart home (Adriansyah & Dani, 2014) (Liu, Lv, & Yong, 2016).

3. Principals of face Recognition System

Face recognition is an action that humans perform routinely and effortlessly in our daily lives. The person identification for the face that appears in the input data is the face recognition process. Face recognition process is shown in Figure 1.

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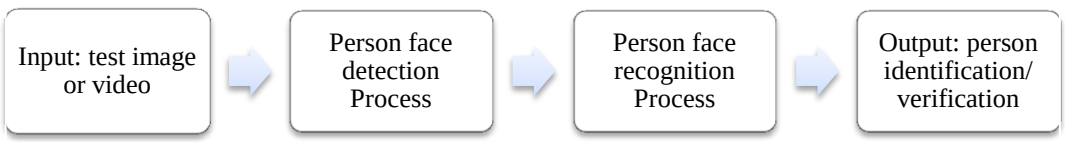

Figure 1: Face recognition process

There are several methods, which are used for person face feature extraction. They are illustrated in Figure 2 (Parmar & Mehta, 2013; Parveeni & Thuraisingham, 2006).

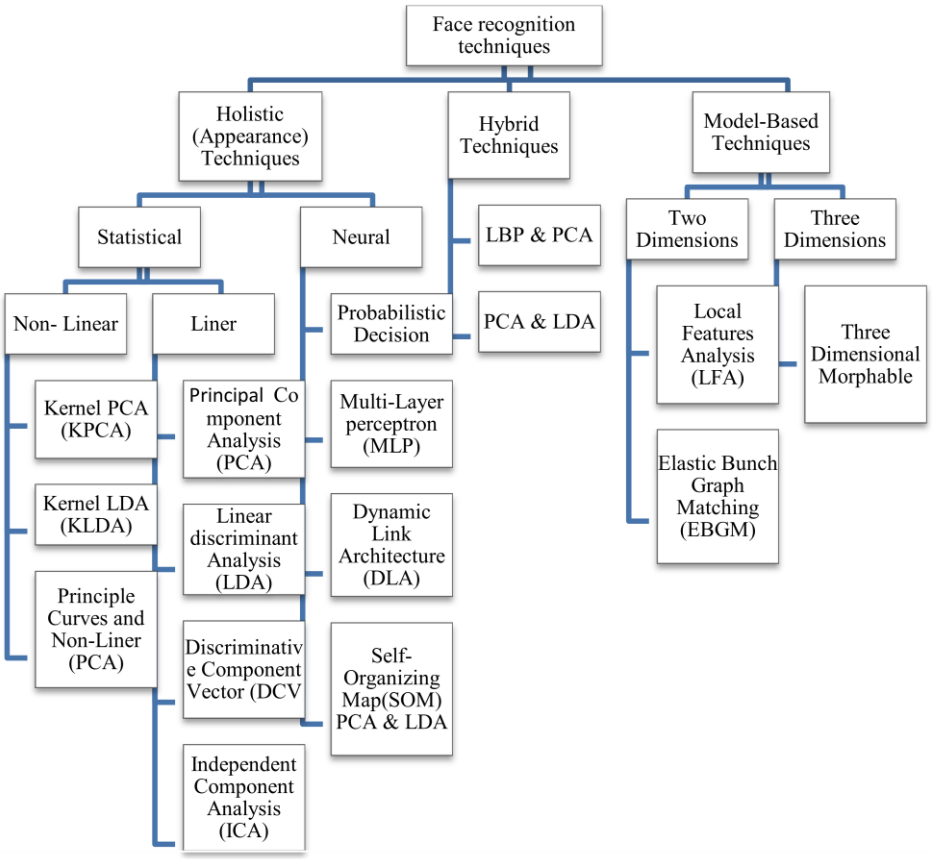

Figure 2: Face recognition approaches

3.1 Model-Based techniques

Face recognition techniques use model-based strategies to develop a model of the person's face that extracts facial features (Wiskott, Fellous, Kruger, & Malsburg, 1997). These strategies made invariant to lighting, a size, and an alignment. In addition, there are other advantages to these techniques, such as rapid matching and compactness of the representation of face images (Kurmi, Agrawal, & Baghel, 2014). In contrast, the main disadvantage of this model is the complexity of face detection (Barnouti, Mahmood, & Matti, 2016).

3.1.1 3D Morphable Model

The 3D strategies for face recognition use the 3D sensor to capture data from the face. This model is classified into two major types: 3D poses estimation and the 3D face reconstruction (Patel & Smith, 2009). In the research of (Hu, Chan, Yan, Christmas, & Kittler, 2014) "A novel Albedo Based 3D Morphable Model (AB3DMM)" is presented. In the proposed method, they used the illumination normalization in a pre-processing stage to remove the illumination component from the images. The results of this research reached 86.76% of recognition on the Multi-PIE database that was used to evaluate SSR + LPQ. In addition, the research of (Ding & Tao, 2016) mentioned that 3D facial landmarks were projected in a grid shape in the 2D image, and then by aligning five facial landmarks

semantically of the corresponding face images with a generic 3D face model.

3.1.2 Elastic Bunch Graph Matching (EBGM)

This algorithm identifies a human in a new appearance picture by comparing his/her new face image with other faces in the database. The process of this algorithm started by extracting feature component vectors using Gabor Jets from a highlighted point on the face. Next, the extracted features are matched to corresponding features from the other faces in the database (Ding & Tao, 2016; Bolme & Strout, 2007).

3.2 Holistic (Appearance) Based Methods

These methods are based on global representations of faces instead of local representation on the entire image for identifying faces. This model takes into consideration global features from the given set of faces in the face recognition process. This model is categorized into three main subspaces: Statistical (Linear (e.g. PCA, LDA, and ICA) and Non- Linear (e.g. KPCA)), Neural (e.g. DLA, MLP) and Hybrid (e.g. PCA with DLP), (Bolme & Strout, 2007; Zafaruddin & Fadewar, 2014).

3.2.1 Principal Component Analysis

This method is used for dimension reduction and feature extractions. Turk and Pentland first used PCA for human face recognition (Bheleet & Mankar, 2012), and person face reconstruction was done by Kirby and Sirovich (Swets & Weng, 1996). This strategy helped to reduce dimensionality of the original data by extracting the main components of multidimensional data (Slavković & Jevtić, 2012). The illumination normalization is very much necessary for Eigenface. Instead of Eigenface, Eigenfeatures like eye, nose, mouth, cheeks, and so forth are used. Calculating the subspace of the low dimensional representation is used for data compression (Sharma & Dubey, 2014; Sandhu, Kaur, Verma, Kaur, & Kumari, 2009; Ibrahim & Zin, 2011).

The work done by Abdullah, Wazzan and Bo-saeed (2012) presented three experiments to enhance PCA efficiency by reducing the computational time while keeping the performance the same. The results showed that the accuracy was the same with the second experiment, with less computational time. According to this approach, the computation time is reduced by 35% as compared with the original PCA method, especially with a large database. Gawande and Agrawal (2014) proposed a new face recognition system for personal identification and verification using different distance classifiers with PCA. This technique applied on the ORL database. The experiment results show that PCA provided improved results using the Euclidean distance classifier and the squared Euclidean distance classifier, then when using the City Block distance classifier, which gives better results than the squared Chebyshev distance classifier. While using the Euclidean and the Squared Euclidean distance classifier, the recognition rate is the same. In addition, Poon, Amin and Yan (2016) presented several techniques for illumination invariant that were examined, and they determined a powerful one for face recognition that works better with PCA. Whereas, Barnouti (2016) illustrates a system using PCA-BPNN with DCT. In this method, PCA combined with BPNN, and from facial recognition view, the technique will distinguish human faces easily. In addition, the face databases are compresses using DCT. The recognition rate of this method is more than 90% that carried out on Face94 and Grimace face databases.

3.2.2 Independent Component Analysis (ICA)

This algorithm is a linear combination of statistically independent data points. The main goal of this technique is in contrast to PCA, which supplies an independent image representation instated of an uncorrelated one of PCA (Hyv¨arinen, Karhunen, & Oja, 2011). ICA minimizes the input of both second-order and higher-order dependencies. It follows the Blind Source Separation (BSS) problem; it aims at decomposing an observed signal into a linear combination of unknown independent signals (Shah, Shah, & Shah, 2014; Toygar & Acan, 2003). The research of Sharma and Dubey (2014) provided a face recognition system using PCA–ICA, and training using neural networks, such as a Hybrid feature extraction. This technique extracts the invariant facial features by implementing a PCA/ICA-based facial recognition system to build a refined and reliable face recognition system. Also, Karande and Badage (2016) have illustrated that the cost function is reduced to maximizing the independence of extracted features as well as the sum of the mutual information between extracted features and a target variable. The global feature extraction is based on edge information, and the local features are based on modular ICA. As a summary, the new technique of feature extraction work will give future direction to the research in the biometric field.

3.2.3 Hidden Markov Model (HMM)

In this approach, face recognition automatically split the faces into different areas, such as the eyes, nose, and mouth (Shah, Shah, & Shah, 2014) (Sun, Chen, & Yin, 2010). The research done by Phaneemdra, Ramachandran and Reddy (2015) presented the insignificant pixels of the face that are taken as blocks and Discrete Cosine Transform (DCT) applied those blocks. In addition, reducing the dimensionality of the result using the PCA algorithm directly makes the technique very fast. The experiments result shows the recognition rate obtained using this method is 95.211% when using half of images for training set from the ORL database.

3.2.4 Kernel Principal Component Analysis (KPCA)

The main idea of KPCA is to first map the input space into a feature space using nonlinear mapping and then to compute the principal components from feature space. In addition, KPCA requires the solution of an eigenvalue problem, which does not require additional optimization. (Kurmi, Agrawal, & Baghel, 2014). In the research done by (Wang & Zhang, 2010) a new method for extracting suitable features and handling face expressions is proposed. In this study, the polynomial kernel had been successfully employed. For classification, they used the Euclidean distance and k-nearest neighbor classifiers. The experiment results were similar to those obtained by traditional PCA-based methods. While, (A, Shekhar, Murthy, & Natarajan, 2015) presented a comparison between Gabor-PCA and Gabor- KPCA variants to show the dissimilarity in performance between them. The results illustrated that the GABOR-PCA was more successful than Gabor-KPCA by 6.67%, 0.83%, 12.00%, and 4.17% using Euclidean, Cosine, City Block, and MARCOS distances respectively based on ORL database.

3.2.5 Linear Discriminant Analysis (LDA)

This algorithm, also called Fisherface, uses a supervising learning method using more than one training image for an individual class. This method searches linear mixtures of features while preserving class independently. In addition, it tries to model the differences among different classes. LDA algorithm is less sensitive to light, poses, and expressions (Murtaza, Sharif, Raza, & Shah,

2014; Sodhi & Lal, 2013).

Hu, Ye, Ji, Zeng and Lu (2015) presented decomposition of an image sample and its transpose performed using Lower-Upper (LU) decomposition algorithm. After that, a projection space evaluation had been done using the Fisher Linear Discriminant Analysis (FLDA). Finally, the Euclidean distance was used as a classifier. This technique was applied to face FERET, AR, ORL, and Yale B databases. The result gives a better efficiency. However, (Soula, Said, Ksantini, & Lachiri, 2016) offered a method of classification using the distinctiveness of Gabor features and the robustness of ordinal measures based on Kernel Fisher Discriminant Analysis. Each feature vector regarded as the feature vector represents a feature input for the proposed Multi-Class KFD classifier based on RBF Kernel. The results obtained on ORL and Yale database showed that the performance has improved as (88.8%) over the LDA (33.3%).

3.2.6 Kernel Linear Discriminant Analysis (KLDA)

The KLDA method consists of nonlinear forms for any method that communicated exclusively. Moreover, using kernel functions that satisfy Mercer's theorem is more economical and efficient (Barnouti, Mahmood, & Matti, 2016; Kamerikar & Chavan, 2014). Jain (2016) used histogram of Oriented Gradient (HOG), and Support Vector Machine (SVM) as classification methods. The result shows that it has good recognition rate. However, Zbeda, Abdulaziz and Saleh (2016) used HOG and PCA techniques. The proposed technique firstly, extracts features at different scales using HOG method; next, PCA is used on these feature vectors for dimension reduction. The experiment results shows an equivalent recognition rate at very small size with a low resolution where the face details are difficult to be distinguished.

4. Distance Measurements and Classification

Several distance measurements methods of face recognition are discussed, as illustrated below:

4.1 Euclidean Distance

It is a common method and it is defined as the straight-line distance between two points, which examines the root of square differences between the coordinates of a pair of images. Euclidean distance is computed using the Equation (1):

$$D(x.y) = \sqrt{\sum_{i=0}^{n}(x_i - y_i)^2} \quad (1)$$

Suppose *x* is a test image and *y* is a training image, where n is the number of images. A minimum Euclidean Distance classifier is used as a condition to find the best- matched test image in the training samples (Yu & Li, 2013).

4.2 Square Euclidean Distance (SED)

This method is obtained without the square roots. It uses a specific equation as shown in Equation (2): (Gawande & Agrawal, 2014; Sodhi & Lal, 2013):

$$\text{Squerd ED}(x.y) = \sum_{i=1}^{No.\ of\ images}(x_i + y_i)^2 \quad (2)$$

4.3 Chebyshev Distance

Chebyshev distance, also known maximum metric. The maximum metric (distance) between two vectors x and y, with standard coordinates x_i andy_i, respectively, is obtained by the Equation (3): (Gawande & Agrawal, 2014; Barnouti, Mahmood, & Matti, 2016):

$$\lim_{n\to\infty}(\sum_{i=1}^{n}|x_{i-}\, y_i|n)^{\frac{1}{n}} \quad (3)$$

4.4 City Block distance

City Block distance, also known Manhattan Distance Classifier. The sum of absolute differences between two vectors is called the L1 distance, or city-block distance. This classifier uses the Equation (4): (Gawande & Agrawal, 2014; Sodhi & Lal, 2013):

$$City\ Block(x.y) = |x-y| = \sum_{i=0}^{No.of\ Images}|x_i - y_i| \quad (4)$$

4.5 K-Nearest Neighbor

The K-NN classifier is a popular classifier for face recognition in terms of speed. In addition, it is the simplest one among other classifier algorithms. While other methods, for example SVM, are better in term of accuracy. The K-NN is based on the closest training samples to test samples on the feature space. (Dhriti & Kaur, 2012).

4.6 Support Vector Machine (SVM) and Multi-Class SVM (MCSVM)

Support Vector Machine (SVM) is one of the most popular techniques in the classification field. The SVM classifier has the advantage over the traditional neural network because it can achieve better generalization performance whereas, Multi-Class SVM has better accuracy as compared with other classifications types (Kaur, 2016; Bheleet & Mankar, 2012).

4.7 Artificial Neural Network (ANN)

In the face recognition area, several categories of ANN had utilized for the classification, such as Retinal Connected Neural Network, Polynomial Neural Network, Convolutional Neural Network, Evolutionary Optimization of Neural Networks, and Back Propagation Neural Networks. The ANN method works like the human brain (AL-Allaf, 2014).

5. Standard Face Databases in Biometric

Biometric systems for recognition based on human faces are bases on several databases. The database shows "usual" variability in facial expression, resolution, pose, gender, age, lighting, background make-up, photographic, quality, accessories, and occlusions (Barnouti, Matti, Al-Dabbagh, & Naser, 2016). Below are some of these databases:

5.1 Face94 Database

This database holds 153 images, each with a resolution of 180x200 pixels, and the directories include images of females and males at independent directories. These images had been captured with glasses, poses, illumination, and expressions for each person independently (Barnouti, Matti, Al-Dabbagh, & Naser, 2016; Akrouf, Sehili, Chakhchoukh, Mostefai, & Youssef, 2014).

5.2 FERET Database

The FERET Database images are divided into two sets: gallery and probe images. The images in the gallery part are with known labels, while the images in the probe part are matched with gallery images for identification (Gumede, Viriri, & Gwetu, 2017).

5.3 AT&T (ORL) Database

The ORL database contains 40 different people (subjects) with 10 images for the individual. The resolution of each image is 92x112 pixels, and the file's extension is stored as a PNG format (Barnouti, 2016; Sodhi, 2013).

5.4 Yale Face Database B

The database images consist of 10 people and recorded in 9 poses (5 poses at 12°, 3 poses at 24°, and 1 frontal view from the camera axis) under 64 different lighting conditions (Barnouti, 2016; Sodhi, 2013).

5.5 Indian Database

The Indian database contains people face images in JPEG, 24-bit RGB format, and the resolution of these images is 180x200 pixels. There are 20 people each one has 20 images. All of the images have a bright homogeneous background, with variant poses (Kamerikar & Chavan, 2014; Barnouti, Matti, Al-Dabbagh, & Naser, 2016).

6. Conclusion

This paper aims at reviewing a significant number of papers to cover the recent development in the field of face recognition. It illustrates the importance of face recognition and its various applications; field, techniques, classification, distance measurements, and face databases. The article reviews a significant number of papers that cover the recent development in the field of face recognition. Several categories of face recognition methods such as appearance-based, model-based and a combination of these two types, named hybrid approaches, processes face recognition have been presented. Face expression, occlusion, pose variation, and illumination problems are still a challenge. Distance Measurement methods such as Euclidean Distance, City Block, etc... that are necessary for recognition process are discussed. In addition, some standard face recognition databases and their properties, e.g. ORL, Indian etc. have been discussed which were used to test any new or modified algorithm performance. Finally, for the more detailed understanding of reviewed approaches, the list of references is enlisted.

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