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. That is because of the wide range of areas they used in. And because of the wide variations of faces, face recognition from the database images, real data, capture images and sensor images is challenging problem and limitation. Image processing, pattern recognition and computer vision are relevant subjects to face recognition field. The innovation of new approaches of face authentication technologies is continuous subject to build much strong face recognition algorithms. In this work, to identify a face, there are three major strategies for feature extractions are discussed. Appearance-based and Model-based methods and hybrid techniques as feature extractions are discussed. Also, 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 organized as follow: 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, face recognizing is considered as standout among the most imperative applications compared to other biometric based systems. The face recognition issues can be stated as follows: Given a database consists of many face pictures of known people and a one input face picture, the process aims to verify or determine the identity of the person in the input image [1]. Biometric-based strategies have developed as the most capable alternative for perceiving people as of late since, 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, natural biological of people cannot be lost, overlooked, stolen or manufactured. For example, physiological characteristics of 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 person verification or identification especially for security systems. Security application witnessed a huge development during the last few decades which is a natural result of the technology 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, the person appears in the video or digital image can automatically be identifying that person by Facial Recognition System (FRS) which is a significant technique to enhance security problems [2]. Recently, many researchers focused on the 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 biometrics, many methods are illustrated here, almost all other innovations require some deliberate activity 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 recognizable proof. Be that as it may, it should be possible using face recognition inactively with no express activity or cooperation with respect to the member since face pictures can be gained

from a distance by a camera. In contrast, low resolution, light, person poses, and illumination variation are some of the drawbacks of faced person recognition. Sometimes person face might be invisible. Therefore, face recognition system provides the 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 [1]-[3]. The idea behind the face recognition system is to determine the known and unknown faces, so a face recognition system is basically, use pattern recognition. Because of the person recognition challenges, such as; faces are highly dynamic and pose, scantiest in this area of pattern recognition, artificial intelligence and computer vision had suggested many solutions to enhance the accuracy and robustness of recognition [4].

1. APPLICATION OF FACE RECOGNITION

Nowadays, the biometric base security application has dramatically increased, especially on face recognition area. Thus, because face recognition application is a powerful way to accurate and robust personal security such as smart home, smart card, law enforcement, surveillance, entrainment [4]-[6]. Table 1. Illustrate the most methods that face recognition are covers.

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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 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 homes or cities has become one of the things that many researchers have focused. For example, design a smart house for people with special needs, patients or the general public to help them meet their needs in the easiest and fastest way. With the development of the devices and the possibility of connecting with the outside world and the use of home appliances remotely using modern technology, for example, facial recognition techniques or speech or gate behavior without the needs to physical connection from the person, such as fingerprint reaction depends on the recognized person prompted researchers to design the smart home depending on the person needs. Hence the importance of using facial recognition techniques to design smart homes.

2. PRINCIPLES 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 appears in the input data is the face recognition process. The face recognition process shown in Figure 1.

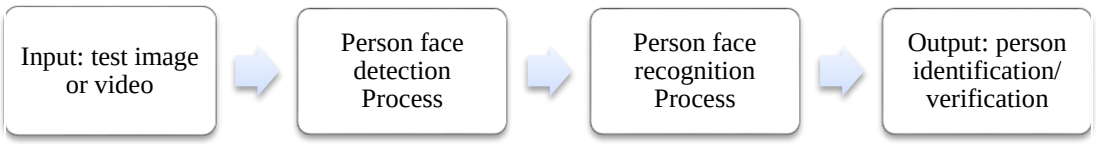
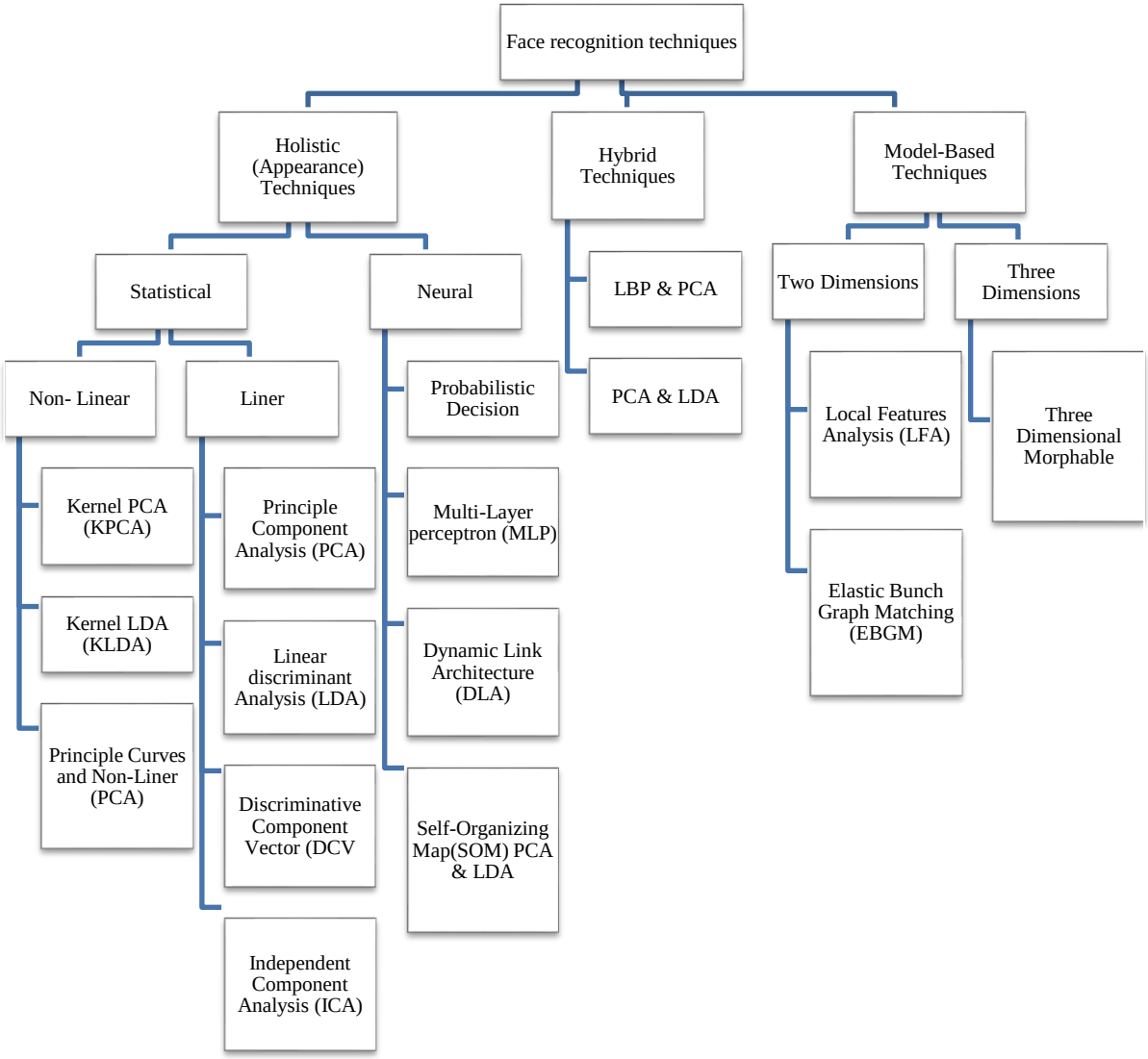


FIGURE 1. Face recognition process

There are several methods used for person face feature extraction which illustrated in Figure 2 [5]-[6].


Face recognition techniques
Holistic (Appearance) Techniques
Hybrid Techniques
Model-Based Techniques
Statistical
Neural
LBP & PCA
Two Dimensions
Three Dimensions
Non- Linear
Liner
Probabilistic Decision
PCA & LDA
Local Features Analysis (LFA)
Three Dimensional Morphable
Kernel PCA (KPCA)
Principle Component Analysis (PCA)
Multi-Layer perceptron (MLP)
Elastic Bunch Graph Matching (EBGM)
Kernel LDA (KLDA)
Linear discriminant Analysis (LDA)
Dynamic Link Architecture (DLA)
Principle Curves and Non-Liner (PCA)
Discriminative Component Vector (DCV
Self-Organizing Map(SOM) PCA & LDA
Independent Component Analysis (ICA)

3.1 MODEL BASED TECHNIQUES

Face recognition techniques uses model-based strategies to develop a model of the person facial that extract facial features [7]. These strategies can be made invariant to lighting, a size and alignment. In addition, other advantages of these techniques such as rapid matching and compactness of the representation of face images [8]. In contrast, the main disadvantage of this model is the complexity of face detection [9].

3.1.1 3D MORPHABLE MODEL

The 3D strategies for face recognition use the 3D sensor to capture data from face. This model can be classified into two major types: 3D poses estimation and the 3D face reconstruction [10]. In the research [11] (Hu et al., 2014) presented "A novel Albedo Based 3D Morphable Model (AB3DMM)" is presented. They used in the proposed method 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 Multi- PIE database which used to evaluate SSR+LPQ. Also, in [12] (Changxing Ding et al. 2016) mentioned that 3D facial landmarks are 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 [13]-[14].

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 face recognition process. This model can be 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) [9], [14]-[15].

3.2.1 PRINCIPLE COMPONENT ANALYSIS:

This method is used for dimension reduction and feature extractions. Turk and Pentland were first used PCA for human face recognition [16], and the person faces reconstruction was done by Kirby and Sirovich [17]. This strategy helped to reduce
the dimensionality of the original data by extracting the main components of multidimensional data [18]-[19]. The face recognition process is based on the new obtained data. The illumination normalization is very much necessary for Eigenfaces. Instead of Eigenfaces, Eigenfeatures like eye, nose, mouth, cheeks, and so forth is used. Calculating the subspace of the low dimensional representation is used for data compression [16], [20]-[23]. The work [24] done by (Abdullah et al., 2012) presented three experiments to enhance PCA efficiency by reducing the computational time while keeping the performance same. The results showed that the accuracy is same with the second experiment with less computational time. According to this approach, the computation time reduced by 35% compared with the original PCA method especially with a large database. While, (Mohit P. Gawande et al., 2014) [25] has proposed a new face recognition system for personal identification and verification using different distance classifiers with PCA. This technique is applied on ORL database. The experiment results show that PCA provided improved results using Euclidian distance classifier and the squared Euclidian distance classifier than the City Block distance classifier, which gives better results than the squared Chebyshev distance classifier. While, using the Euclidian and the Squared Euclidian distance classifier, the recognition rate is the same. In addition, (Poon et al., 2016) [26] presented several techniques for illumination invariant were examined and determine powerful one for face recognition that works better with PCA. The selected technique is named Gradient faces and at the pre-processing stage the experimental results showed that improves the recognition rate. Whereas, (Barnouti, N.H., 2016) [27] Illustrate a system using PCA-BPNN with DCT. In this method, PCA is combined with BPNN, and from face recognition view, the technique

will distinguish human faces easily. Also, the face databases are compressed using DCT. The recognition rate of this method is more than 90% that carried out on Face94 and Grimace face databases. In contrast, (Fares Jalled 2017) [28] Proposed "Normalized Principal Component Analysis (NPCA) for face recognition". The experiment result of face recognition performance rate is carried out on the ORL and Indian Face Database.

3.2.2 INDEPENDENT COMPONENT ANALYSIS (ICA)

This algorithm is a linear combination of statistically independent data points. The main goal of this technique in contrast of PCA which supply an independent image representation instated of uncorrelated one of PCA [29]. ICA minimizes the input of both second-order and higher-order dependencies. It follows the Blind Source Separation (BSS) problem; it aims to decompose an observed signal into a linear combination of unknown independent signals [30]-[31]. The research [32] (Sharma and Dubey, 2014) provided face recognition system using PCA–ICA, and training using neural networks as a Hybrid feature extraction. This technique extracts the invariant facial features by implementing PCA/ICA-based facial recognition system to build a refined and reliable face recognition system. Also, in [33] (Kailash J. et al., 2016) it has been 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 based on edge information, and the local features based on modular ICA which is used in this research. As a summary, the new technique of feature extraction work will give future direction for the research in biometrics field.

3.2.3 HIDDEN MARKOV MODEL (HMM)

This approach is used within speech application. Using this method in face recognition will automatically split the faces into different areas, such as the eyes, nose, and mouth, which can be related with the situations of an HMM [30]-[34]. (P. Phaneemdra et al.,2015) [35] presented that, the insignificants pixels of the face have been taken as blocks and apply the Discrete Cosine Transform (DCT) on face image's blocks. Also, reducing the dimensionality for the result of applying the DCT using PCA method directly which makes the technique very fast. The experiments show the recognition rate obtained using this method is 95.211% when using half of the images for training from 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 calculate the principal components in that feature space. Also, KPCA requires the solution of an eigenvalue problem, which does not requires additional optimization. Furthermore, the number of principal components need not be specified previously to modeling [8].

(Wang and Zhang, 2010) [36] Proposed a new method for extracting suitable features and handling face expressions. In this study, the polynomial kernel is successfully employed. Also, for classification, they used the Euclidean distance and k-nearest neighbor. The experiment results are similar of these obtained by traditional PCA-based methods. While, (Vinay et al., 2015) [37] presented a study, a comparison between Gabor-PCA and Gabor-KPCA variants has performed to show the dissimilarity in performance between them. The comparison used the ORL database to test the system performance. 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 MAHCOS distances respectively.

3.2.5 LINEAR DISCRIMINANT ANALYSIS (LDA)

This algorithm also is called Fisherface which uses a supervising learning method by it using more than one training image for individual class. Also, this method searches linear mixtures of features while conserving class separately. In addition, it is tries to model the differences among different classes (unlike PCA algorithm) and it distinguishes between the differences inside a person and the others persons. Whereas, PCA emphases on discovering the all-out variation within a pool of pictures. LDA is less sensitive to light, pose, and expressions [38],[46]. (Changhui Hu et al. 2015)[39] presented decomposition of an image sample and its transpose is performed by the reverse thinking method which is applied by using experimental analysis, using the Lower-Upper (LU) decomposition algorithm. After that, a projection space evaluation is done using the Fisher Linear Discriminant Analysis (FLDA). Finally, the Euclidean distance is adapted as classifier. This technique is applied on face FERET, AR, ORL and Yale B databases and the results gives a better efficiency. While, Arabia SOULA et al, 2016[40] offered a method of classification using the distinctiveness of Gabor features and the robustness of ordinal measures based on Kernel Fisher Discriminant Analysis. The face image blocks are concatenated and the PCA is used

in dimension reduction of a feature vector. Each feature vector is considered as a feature input for the proposed Multi-Class KFD classifier based on RBF Kernel is represented by the feature vector. The results obtained on ORL and Yale face showed that the performance improved as (88.8%) over the LDA (33.3%).

3.2.6 KERNEL LINEAR DISCRIMINANT ANALYSIS (KLDA)

Kernel algorithm exploits the higher order statistics. This technique can calculate the dot products of two feature vectors. The kernel strategy constructs of nonlinear forms for any method that can be communicated exclusively in term of dot products results. And increase in dimensionality is given, the mapping is done by using kernel functions that satisfy Mercer's theorem which is more economical and efficient [9],[41]. In [42] (Naveen Kumar H N et al.) , Histogram of Oriented Gradient (HOG) elements, and Support Vector Machine (SVM) is utilized for characterization. The proposed work is applied on Cohn-kanade data index for six essential expressions. The result showed that, it has a superior rate when shape and appearance elements are utilized as opposed to surface or geometric elements. But, in (Farag G. Zbeda et al. 2016) [43] they used HOG and PCA techniques, the proposed technique firstly, extracted features at different scales using HOG method, next, PCA used on these feature vectors. The experiment results show gives an equivalent recognition rate at very small size with a low resolution where the face details are hard to be distinguished.

4. DISTANCE MEASUREMENTS AND CLASSIFICATION

There are several distance measurements methods for face recognition are used 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 computed using the Equation (1)

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

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 [45].

4.2 SQUARE EUCLIDEAN DISTANCE (SED)

This method is obtained without the square roots. The equation becomes as shown in Equation (2): [25],[46]:

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

4.3 CHEBYSHEV DISTANCE

Chebyshev distance also is known maximum metric. The maximum metric (distance) between two vectors x and y, with standard coordinates x_i and y_i, respectively, is obtained by the Equation (3): [25],[9]

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

4.4 CITY BLOCK DISTANCE:

This method also is known Manhattan Distance Classifier. The sum of absolute differences between two vectors is called the L1 distance, or city-block distance. This classifier used the Equation (4): [25],[46]:

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

4.5 K-NEAREST NEIGHBOR

The K-NN classifier is a popular classifier for face recognition in terms of time consuming. Also, this classifier is the simplest one among other classifier algorithms. While other methods for example SVM is better in term of accuracy. The K-NN is based on the closest training samples on the feature space. The input image test recognized due to the nearest point with the training images data set [47].

4.7 SUPPORT VECTOR MACHINE (SVM) AND MULTI-CLASS SVM (MCSVM)

Support Vector Machine (SVM) is one of the most popular techniques in classification problems. A classification algorithm that has successfully been used in this framework is the all-known (SVM). In contrast, this method cannot be applied only when the feature vectors defining samples have missing entries. The SVM classifier has the advantage over the traditional neural network which it can achieve better generalization performance and Multi-Class SVM has better performance and accuracy with other classification types [48]-[49].

4.8 ARTIFICIAL NEURAL NETWORK (ANN)

It is a well-known and robust classification technique which is used for face recognition systems. In the face recognition process, several structures of ANN are utilized for classification, such as Retinal Connected Neural Network, Polynomial Neural Network, Convolutional Neural Network, Evolutionary Optimization of Neural Networks and Back Propagation Neural Networks. The importance of this classifier because of its reacts as human brain [50].

5. STANDARD FACE DATABASES IN BIOMETRIC

Biometric systems for recognition based human faces are based on several databases. The database shows “usual” variability in facial expression, resolution, pose, gender, age, lighting, focus, background make-up, photographic, quality, accessories, occlusions, and race. [27],[51]. Below some of these databases:

5.1 FACE94 DATABASE

The Face 94 database holds 153 images, each with a resolution of 180x200 pixels, and the directories include images of female and male persons in separate directories. Some of the images are taken with glasses, and a mixture of tungsten and fluorescent overheads and the lighting is artificial [51]-[52].

5.2 FERET DATABASE

The images included in this database are parted into two sets: gallery and probe images. The images in Gallery parts are with known labels, while the images in probe part are matched with gallery images for identification [53].

5.3 AT&T (ORL) DATABASE

The ORL database contains 40 different persons (subjects) with 10 images for the individual person, with the total of 400 images. The resolution of each image is 92x112 pixels, for a total of 10,304 pixels, and the file's extension is stored in PGM format [44],[54].

5.5 YALE FACE DATABASE B

The database images consist of 10 persons 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 [44],[54].

5.7 INDIAN DATABASE

The Indian contains person face images in JPEG, 24-bit RGB format, and the resolution of these images is 180x200 pixel portrait formats with the plain background. There are 20 persons each having 20 images. All the images have a bright homogeneous background, with variant positions [41],[51].

6. CONCLUSIONS

This paper has attempted to review a significant number of papers to cover the recent development in the field of face recognition. This paper has attempted to illustrate the importance of face recognition and its various applications field, techniques, classification, distance measurements, face databases are deliberated. Also, review a significant number of papers to cover the recent development in the field of face recognition. Face recognition is done by several types of algorithms – appearance-based and model-based or combination of this tow types named hybrid approaches. Present research reveals that for enhanced face recognition new algorithm must evolve using hybrid methods. Face expression, occlusion, pose variation and illumination problems are still challenging. Distance Measurement methods such as Euclidean Distance, City Block ... etc. are necessary for recognition process are discussed. In addition, some of the standard face recognition databases and its properties such as ORL, and Indian etc., are discussed which are used to test any new proposed system performance. Finally, for more detailed understanding of reviewed approaches, the list of references is enlisted.

REFERENCES

[1] Rabia Jafrial, "A Survey of Face Recognition Techniques", Journal of Information Processing Systems, Vol.5, No.2, June 2009.

[2] Ghazi Mohammed Zafaruddin et al., "Face Recognition: A Holistic Approach Review", IEEE, 2014.

[3] Ardinintya Diva Setyadi et al., "Human Character Recognition Application Based on Facial Feature Using Face Detection", IEEE, International Electronics Symposium (IES), 2015.

[4] Stan Z. Li and Anil K. Jain, "Handbook of Face Recognition", Springer, ISBN 978-0-85729-931-4, e-ISBN 978-0-85729-932-1, Second Edition, 2011.

[5] Divyarajsinh N. Parmar et al., "Face Recognition Methods & Applications ", IJCTA, Int.J.Computer Technology & Applications, Vol. 4 (1), 84-86, ISSN: 2229-6093, 2013.

[6] Pallabi Parveenet al.," Face Recognition using Multiple Classifiers", Proceedings of the 18th IEEE International Conference on Tools with Artificial Intelligence (ICTAI'06) 2006.

[7] Laurenz Wiskott et al., " Face Recognition by Elastic Bunch Graph Matching", In Intelligent Biometric Techniques in Fingerprint and Face Recognition, eds. L.C. Jain, publ. CRC Press, ISBN 0-8493-2055-0, Chapter 11, pp. 355-396, (1999).

[8] Uma Shankar Kurmi et al. "Study of Different Face Recognition Algorithms and Challenges", International Journal of Engineering Research (ISSN:2319-6890)(online),2347-5013(print),Volume No.3, Issue No.2, pp:112-115 01 Feb. 2014.

[9]Nawaf Hazim Barnouti et. al., "Face Recognition: A Literature Review", International Journal of Applied Information Systems (IJAIS) – ISSN: 2249-0868 Foundation of Computer Science FCS, New York, USA Volume 11 – No. 4, September 2016 – www.ijais.org, 2016.

[10] Ankur Patel et al., "3D Morphable Face Models Revisited", 978-1-4244-3991-1/09, IEEE, 2009.

[11] Guosheng Hu et al., "Robust face recognition by an albedo based 3D morphable", 2014.

[12] Changxing Ding et al. "Pose-invariant face recognition with homography-basednormalization",Elsevier,http://dx.doi.org/10.1016/j.patcog.2016.11.024; Accepted 28 November 2016.

[13] Deepali H. Shah et al.," The Exploration of Face Recognition Techniques ", International Journal of Application or Innovation in Engineering & Management (IJAIEM) Volume 3, Issue 2, February 2014 ISSN 2319 – 4847, 2014.

[14] Michelle Strout et al, "FacePerf: Benchmarks for Face Recognition Algorithms",Conference Paper October 2007 DOI: 10.1109/IISWC.2007.4362187 · Source: IEEE Xplore, 2007.

[15] Ghazi Mohammed Zafaruddin et al., "Face Recognition: A Holistic Approach Review", IEEE, 2014.

[16] Sujata G. Bheleet al., "A Review Paper on Face Recognition Techniques", International Journal of Advanced Research in Computer Engineering & Technology (IJARCET), Volume 1, Issue 8, October 2012.

[17] Yong Xu et al., "Using Discriminant Eigenfeatures for Image Retrieval", IEEE, Transaction on pattern analysis and machine intelligence, VOL. 18, NO. 8, AUGUST 1996 .

[18] Marijeta Slavković et al., "Face Recognition Using Eigenface Approach", Serbian journal of electrical engineering,Vol. 9, No. 1, February 2012, 121-130.

[19] Nawaf Hazim Barnouti et al.,"Improve Face Recognition Rate Using Different Image Pre-Processing Techniques", International Journal of Computer Applications (0975 – 8887) Volume 142 – No.6, May 2016.

[20] Nilind Sharma et al.," Face Recognition Analysis Using PCA, ICA and Neural Network", International Journal of Digital Application & Contemporary research Website: www.ijdacr.com (Volume 2, Issue 9, April 2014).

[21] Krishna Dharavath et al., "Improving Face Recognition Rate with Image Preprocessing", Indian Journal of Science and Technology, Vol 7(8), 1170–1175, August 2014.

[22] Parvinder S. Sandhu et al., "Face Recognition Using Eigen face oefficients and Principal Component Analysis", International Journal of Computer, Electrical, Automation, Control and Information Engineering Vol: 3, No: 4, 2009.

[23] Ratnawati Ibrahim et al., "Study of Automated Face Recognition System for Office Door Access Control Application", IEEE, 2011.

[24] Manal Abdullah et al., "OPTIMIZING FACE RECOGNITION USING PCA", International Journal of Artificial Intelligence & Applications (IJAIA), Vol.3, No.2, March 2012.

[25] Mohit P. Gawande et al., "Face recognition using PCA and different distance classifiers" IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834, Volume 9, Issue 1, Ver. VI (Feb. 2014), PP 01-05.

[26] Bruce Poon et. al., "PCA Based Human Face Recognition with Improved Methods for Distorted Images due to Illumination and Color Background", IAENG International Journal of Computer Science, 43:3, IJCS_43_3_02, 2016.

[27] Nawaf Hazim Barnouti, "Face Recognition using PCA-BPNN with DCT Implemented on Face94 and Grimace Databases International Journal of Computer Applications (0975 – 8887) Volume 142 – No.6, May 2016.

[28] Fares Jalled, "Face Recognition Machine Vision System Using Eigenfaces", arXiv: 1705.02782v1 [cs.CV] 8 May 2017.

[29] Aapo Hyv¨arinen et al., "Independent Component Analysis", A WileyInter science Publication, JOHN WILEY & SONS, INC,2001.

[30] Deepali H. Shah et al., "The Exploration of Face Recognition Techniques", International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 3, Issue 2, February 2014.

[31] Önsen et al., "FACE RECOGNITION USING PCA, LDA AND ICA APPROACHES ON COLORED IMAGES", ISTANBUL UNIVERSITY – JOURNAL OF ELECTRICAL & ELECTRONICS ENGINEERING, 2003.

[32] Nilind Sharma et al., "Face Recognition Analysis Using PCA, ICA And Neural Network International Journal of Digital Application & Contemporary research Website: www.ijdacr.com (Volume 2, Issue 9, April 2014).

[33] Kailash J. Karande et al., "Facial Feature Extraction using Independent Component Analysis", Annual Int'l Conference on Intelligent Computing, Computer Science & Information Systems (ICCSIS-16) April 28-29, 2016 Pattaya (Thailand).

[34] Yi Sun, Xiaochen Chen et al., "Tracking Vertex Flow and Model Adaptation for Three-Dimensional Spatiotemporal Face Analysis", IEEE: System and humans, VOL. 40, NO. 3, MAY 2010.

[35] P. PHANEEMDRA et al., "Human Face Detection and Recognition using PCA and DCT in HMM", International journal of scientific engineering and technology research, ISSN 2319-8885 Vol.04, Issue.35, pp.: 7080-7085, 2015.

[36] Yanmei Wang et al., "Facial Recognition Based on Kernel PCA", Third International Conference on Intelligent Networks and Intelligent Systems, 2010.

[37] Vinay.A et al., "Face Recognition using Gabor Wavelet Features with PCA and KPCA - A Comparative Study", 3rd International Conference on Recent Trends in Computing (ICRTC-2015).

[38] Marryam Murtaza et al., "Face Recognition Using Adaptive Margin Fisher's Criterion and Linear Discriminant Analysis (AMFC-LDA)" , The International Arab Journal of Information Technology, Vol. 11, No. 2, March 2014.

[39] Changhui Hu et al., "A new face recognition method based on image decomposition for single sample per person problem", Neurocomputing, http://dx.doi.org/10.1016/j.neucom. 2015.

[40] Arbia SOULA et al., "A Novel Kemelized Face Recognition System" , Proceedings of 2016 4th International Conference on Control Engineering & Information Technology, Tunisia, Hammamet- December, 16-18, 2016.

[41] Umesh Ashok Kamerikar et al., "Experimental Assessment of LDA and KLDA for Face Recognition", International Journal of Advance Research in Computer Science and Management Studies, ISSN: 2321-7782 (Online), Volume 2, Issue 2, February 2014.

[42] Naveen Kumar H N et al., "Human Facial Expression Recognition from Static Images using Shape and Appearance Feature", IEEE, 2016.

[43] Farag G. Zbeda et al., "PCA-HOG Descriptors for Face Recognition in very Small Images", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 6, Issue 9, September 2016.

[44] Nawaf Hazim Barnouti et al., "Improve Face Recognition Rate Using Different Image Pre-Processing Techniques", American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN: 2320-0936 Volume-5, Issue-4, pp-46-53, 2016.

[45] Jiali Yu et al., "Face Recognition Based on Euclidean Distance and Texture Features", IEEE, International Conference on Computational and Information Sciences, 2013.

[46] Kuldeep Singh Sodhi et al., "FACE RECOGNITION USING PCA, LDA AND VARIOUS DISTANCE CLASSIFIERS", Journal of Global Research in Computer Science, Volume 4, No. 3, March 2013.

[47] Dhriti et al., " K-Nearest Neighbor Classification Approach for Face and Fingerprint at Feature Level Fusion International Journal of Computer Applications (0975 – 8887) Volume 60– No.14, December 2012.

[48] Navpreet Kaur, "Review of Face Recognition System Using MATLAB", International Journal of Computer Science Trends and Technology (IJCST) – Volume 4 Issue 3, May - Jun 2016.

[49] Supriya D. Kakade, "A Review Paper on Face Recognition Techniques", International Journal for Research in Engineering Application & Management (IJREAM), ISSN: 2494-9150 Vol-02, Issue 02, MAY 2016.

[50] Omaima N. A. AL-Allaf, " REVIEW OF FACE DETECTION SYSTEMS BASED ARTIFICIAL NEURAL NETWORKS ALGORITHMS", The International Journal of Multimedia & Its Applications (IJMA) Vol.6, No.1, February 2014.

[51] Nawaf Hazim Barnouti et al., "Face Detection and Recognition Using Viola-Jones with PCA-LDA and Square Euclidean Distance", International Journal of Advanced Computer Science and Applications, Vol. 7, No. 5, 2016.

[52] Kiran D. Kadamet al., "Face Recognition using Principal Component Analysis with DCT" , International Journal of Engineering Research and General Science Volume 2, Issue 4, ISSN 2091-2730, June-July, 2014.

[53] A. Gumedeal. , "Hybrid Component-based Face Recognition", IEEE, 2017.

[54] Kuldeep Singh Sodhi, "Comparative Analysis of PCA-based Face Recognition System using different Distance Classifiers", International Journal of Application or Innovation in Engineering & Management (IJAIEM), ISSN 2319 - 4847 ,Volume 2, Issue 7, July 2013.