# Exploring in Face Recognition Approaches

**Muthana Hamd , Adel Al-Jumaily , Laith M. Mohammad**
Engineering & IT Faculty, UTS, Sydney, Australia
Computer & Software Eng. Department, Al –Mustansirya, Iraq

**Abstract** - *Biometric recognition system refers to the automatic recognition of human beings based on their physiological and/or behavioral characteristics. First, a general Automatic Face Recognition (AFR) system framework is proposed to illustrate the processing stages of face images. The AFR includes two main phases: the enrolment phase and recognition/verification phase. Secondly, the main methods of human face recognition are presented, described and compared. Different popular and modern algorithms that have been applied on living persons to verify or recognize the identity based on his/her physiological characteristic are reviewed in this paper. Also, recent face dataset is tabulated to assist the researchers how to find proper database in their applications.*

**Keywords:** AFRS, face detection approaches, face recognition/verification

## 1 Introduction

Human face plays a major role in conveying identity and motion. Face detection is a computer technology based on appropriate algorithm that determines the human poses and sizes in images.

It is considered a specific case of object-class detection. Object detection deals with finding and localizing specific objects in images and video [1], whereas face detection detects facial features and expressions and ignores other things. Many face detection algorithms have been applied on this field. Early algorithms were focused on the detection of frontal face view, whereas recent algorithms deal with more difficult problems like: 3dimensions (3D), face size, face position, number of faces in image, orientation, face expression, illumination (change the color and appearance of the face), and occlusions (can be caused by objects within the environments)

Therefore, the new computational models of face recognition are quite difficult because faces are complex, multidimensional, and meaningful stimuli.

In information technology, biometrics is used as a form of identity access management and access control. It is also used to identify individuals in groups that are under surveillance. Face detection is used in biometrics, often as a part of a facial recognition system. Although it emerged from its extensive use in law enforcement to identify criminals, it is widely used to establish person recognition/verification in many applications. Biometrics is humans recognizing methods based upon one or more inherent physical or behavioural characteristics. Biometric system can be operates by acquiring biometric data from a living person, extracting a feature set from these data, and comparing this feature set against the template set in the database. It operates in two modes: Identification Mode and Verification Mode. In identification mode, the system conducts one-to-many comparison to establish a person's identity, while in the verification mode, the system conducts a one-to-one comparison to determine whether the person is valid or not. Generally, a facial recognition system can be categorized in two main areas:

### 1.1 Skin texture based method

The visual details of a skin could be capture by using an emerging trend as in standard digital or scanned images. We called this technique, the skin texture analysis. This area has a problem formulation that starts by turning the unique lines, patterns, and spots apparent in a person's skin into a mathematical model.

### 1.2 Geometric/image based method

The method of recognizing a 3D object depends on the properties of an object. 3D approaches in face recognition categorized into two main parts:

- Template-Based approach
- Feature Based Approach

The template-based approach is represented as a set of templates of the major facial features and involve a classifier likes a neural networks. While feature-based geometric approaches construct a model for the object to be recognized, and match the model against the photograph. Feature based approach extracts and normalizes a vector of geometric descriptor of biometric facial components such as eyebrow, chin shape, mouth…etc. One advantage of 3-D facial recognition is that it is not affected by changes in lighting like other techniques. It can also identify a face from a range of viewing angles, including a profile view.

The main aim of this paper provides comprehensive review to the recent modern and popular approaches that deal with face recognition or verification and make practitioners aware of the benefits of face recognition or verification techniques and in some cases even the necessity of applying such techniques. Therefore, we

provide an overview of the different types of techniques for classification: we illustrate them by reviewing the most important application fields in the Automatic Face Recognition domain, highlighting the efforts done by the AFR community in developing novel and adapted procedures. Finally, we also point the interested reader to some useful database can be used for AFR testing. This paper organized as follows: in section 2, a general AFR system is proposed and described. Four modern approaches are illustrated in section 3. Five recent popular algorithms are described in section 4. Finally, we summarize the most important conclusions regarding to the diversity of face detection algorithms.

# 2 General AFR System

A typical Automatic Face Recognition (AFR) system in [2] is composed of three parts: face detection, face alignment and face recognition. A general AFR system operates by acquiring biometric data from a living person, extracting a feature set from the acquired data, and comparing this feature set against the template set in the database. Database template can be constructed during enrollment phase where, the face image is acquired using a camera/scanner and stored in a database as a template. Fig. 1 illustrates our proposed general AFR system. It contains two main phases:

1) Enrolment phase which include:
   - face image acquisition,
   - face detection, and
   - training

2) Recognition/verification phase which include:
   - feature extraction,
   - facial image classification, and
   - decision

## 2.1 Template database building phase

Enrollment phase includes detection and training pre-processing for face images that have been acquired using a digital camera/scanner before storing them as a user identity templates database. One example of many standard database templates that can be used in recognition process is the Olivetti Research Laboratory (ORL) database [3]. It contains ten different images for each of 40 distinct subjects, each subject forming the "neutral" expression and other six expressions. The data of the input images must be normalized by passing thru standardize process to be ready for next processes as shown in Fig.1. Face images pre-processing may include color conversion, illumination reducing, size normalization which is an important techniques in face recognition/verification enhancement.

## 2.2 Recognition/Verification phase

The biometric data of a user's face is either to identify (one-to-many map) or verify (one-to-one map) the claimed identity of the user. The input to the face recognition/verification block is face images, which are derived from two sources: from the camera/scanner and from the database as shown in Fig.1. The result of the classification is determined by matching the client index with the client template in the database

# 3 Modern Detection Approaches

Algorithms have been developed to be more effective and precise in processing face images. To get high accuracy of these algorithms, it causes to processing huge amount of images in existing databases. There is no clear classification to the face detection algorithms or approaches, although [4].Specifies three popular algorithms, they are: Viola-Jones object detection framework, A Statistical Method for 3D Object Detection Applied to Faces and Cars by Schneiderman & Kanade, and Neural Network-Based Face Detection by Henry A. Rowley, Shumeet Baluja, and Takeo Kanade. We supposed that all recent developed approaches or the ones that have not been applied on face detection process before are modern approaches. Four approaches have been viewed in next sections.

## 3.1 Markovian stochastic

Markovian stochastic mixture approach is proposed by Ming Zhao [5], it is combining bottom-up and top-down flowchart for an automatic face recognition system. They modeling the Markovian stochastic mixture approach as approach a stochastic process as explained in Fig. 2. The identified person is decided probabilistically based on the stochastic process of face recognition as a Markov chain. A discriminative face alignment procedure is proposed to provide accurate localization for features extraction instead of conventional face alignment which concentrates on general purpose face alignment. Active Shape Models (ASM) which proposed in [5] is able to provide accurate alignment for itself and band alignment for others because of its strength discriminative face alignment. They proof that face recognition results depends on discriminative face alignment only, not on conventional face alignment. A viable stochastic model for the spatial distribution of gray levels is proposed by Sarat C. Dass et al [6]. They applied Markov Random Fields (MRFs) models for training and human faces detecting. The models are trained using faces and non-faces images database.

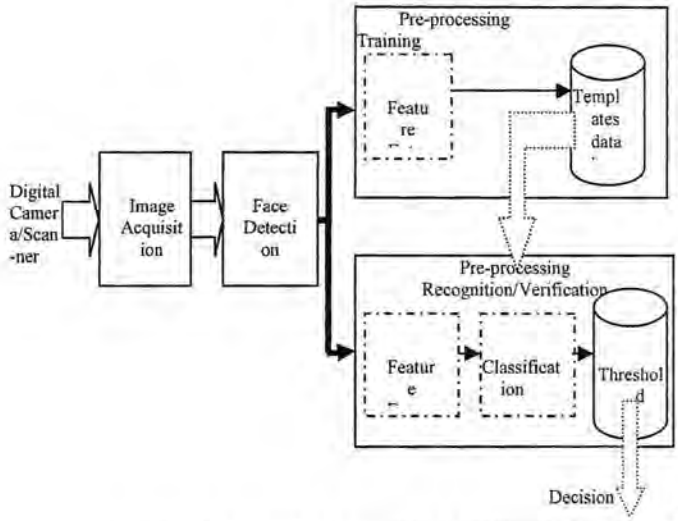


Fig.1 Face Enrollment and recognition/validation block diagram

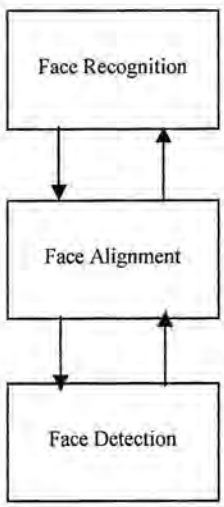


Fig. 2. Mixture Face Recognition Strategies

## 3.2 Compressed sensing approach

Compressed Sensing (CS) applications can be found in [7], [8], [9], and [10]. The algorithms and hardware proposed by Shang-Hung Lin et al [8] to support a new theory of compressive imaging is very interesting. The new digital image /video camera can directly acquires of random projections of the signal without collecting the pixels/voxels firstly. The computation required for video acquisition/encoding has been reduced due to camera ability to obtain an image with single detection element.

A new mathematical theory and Compressed Sensing (CS) algorithm have been applied to fit the face recognition task by Nhat Vo et al [7]. The idea of CS in [7] is the new input sample as a sparse linear combination of training samples; they used Yale Database, ORL Database and Extended Yale B Database. Also they used the Euclidean metric distance in the framework.

Other important applications of CS include: the Magnetic Resonance Imaging (MRI) in the medical imagining provided by [9], DNA Microarrays based CS was studied also in [10].

## 3.3 Components and their topology

A components-based approach was proposed by Mohan [11] for a fully body person detection. A collection of components like; head, legs, right arm, and left arm could be described a person. The possible scales and positions for each component detector could be determining by Heuristic rules. The individual components are searched by a predefined sub-region using Haar Wavelets and the classification is based on Support Vector Machine (SVM). Recent developments of human visual perception proposed system is based on a component based approach. Facial component can be detected individually, followed by a topology verification and face localization step. A well defined novel system Viola and Jones approach presented by Lutz et al [12] combines techniques from both statistical and structural pattern recognition domain to achieve high robustness in the presence of partial occlusions. The Graph model succeeded providing a method to estimate the position and size of wildcard components. The face region can be derived if the components are detected or estimated.

## 3.4 Rotation invariant multi view face detector

A series of development methods are proposed by Chang Huang et al [13] to construct a high-performance rotation invariant multi-view face detector, they develop Width First Search Tree Structure (WFS) by partitioning the complicated detection task into individual view. The tree decision and the Pyramid approach in [13] were based on the tree approach in [14] to partition the detection task in terms of coarse-to-fine strategy and organize them moderately. The Vector Boosting algorithm is proposed for learning the vector output dataset, the sparse feature in granular space, and the heuristic search for sparse feature selection. It supposed that face detection task has two mainly methodologies: knowledge-based and learning based. Experiments of [13] was achieved by collecting and manually labeling 30,000 frontal faces, 25,000 half-profiles ones, and 20,000 full profile ones for Multi View Face Detection (MVFD) training. These samples train a quartered upright multiview face detector with WFS tree structure. The experiments results on several standard testing sets achieve significant improvement in both speed and accuracy.

## 4 Face Detection Popular Approaches

The most popular subspace analysis approaches in face recognition: Eigenfaces (PCA), Neural Networks (NNs), Support Vector Machine (SVM), Linear Discriminate Analysis (LDA) [14, 15], Fisherfaces, and Laplacianfaces [14], [15], [16], and [17].

### 4.1 Eigenfaces

Principle Component Analysis (PCA) derived from Karhunen-Loeve's transformation. It is a statistical dimensionality-reduction method, which produces the optimal least-squares decomposition of a training set.

PCA prepares to find an N-dimensional subspace from a given M-dimensional vector that represents the training set of images for each face. The new subspace vectors reflect the maximum variance direction in the original image space with (N<<M).

PCA and Independent Component Analysis are linear subspace methods have been used extensively in many science and engineering fields, ranging from neuroscience to computer vision, and pattern recognition. Both two methods try to find a new space to represent data. The difference is how to find the basic vectors of the spaces [18]. PCA reduces high dimensionality data, by projecting onto a subspace that contains the intrinsic structure of the data. The aim is to find the uncorrelated components that preserve as much of the data variance as possible [19] [20]. PCA is unsupervised statistical method could be widely used for face representation. It finds a set of basic image and represents faces as a linear combination of those images. We called the subspace basis vectors that have been computed by PCA "Eigenfaces". PCA approach has two phases:

1) Training Phase: an eigenspace is established from the training samples using PCA and the training face images are mapped to the eigenspace from a classifier.
2) Classification Phases: an appropriate classifier is used to classify the input face images that are projected to the same eigenspace

Algorithms of PCA have been applied in different studies including face detection (Moghaddam and Pentland 1995; Sung and Poggio 1998), face recognition (Fleming and Cottrell 1990; Turk and Pentland 1991; Brunelli and Poggio 1993; Hancock et al 1996) [3]. The first attempt to semi-automated face recognition with a hybrid human-computer system was by Bledsoe (1966a,b). He classified the faces on the basis of distinct marks made on photograph by hand. Classification parameters such as eye corners, mouth corners, nose tip, and chin point were normalized distances and ratios. A developed vector of up to 21 features was made by Goldeston, Harmon, & Lesk, 1971 at Bell Labs. Faces were recognized using standard pattern classification technique. The features were largely subjective evaluations and quite difficult to automate.

Turk and Pentland developed a two –dimensional (2-D) computational approach which simulate a real-time computer system to locate and track a subject's head. The proposed approach was based on both the physiology and information theory and it recognizes the person by comparing face characteristics to those of known persons. A particular face recognition procedure was achieved by comparing the weighted sum of the eigne face features with those of known individuals. The approach was easy to implement using neural network architecture [15]. A real time face recognition system is proposed and implemented by Nicolas Morizet [21]. The PCA face recognition system algorithm is applied on different architectures to design a best real time face recognition system, they used PCA algorithm because of its lowest time consuming. The use of PCA transforming based on hybrid configurations for different color component images are proposed by [22]. They presented a face recognition method by using a new representation. Different popular methods like PCA, Fisher Linear Discriminate (FLD) and other new face recognition approaches are compared by [7] to identify the role of color in face recognition. A hardware oriented algorithm for Eigenface based face detection using Fast Fourier Transform (FFT) is described by Sudha [11]. They derived the FFT-based computation of distance measure to facilitate hardware implementation and fast face detection.

### 4.1 Independent component analysis

Independent Component Analysis (ICA) minimizes both second-order and higher-order dependencies in the input data and attempts to find the basis along which the data are statistically independent. ICA can generate basis vectors, like PCA, with more spatial, localized and representative.

The basis images found by PCA depend only on pair-wise relationships between pixels in the image database as PCA considers the 2nd order moments only, it lacks information on higher order statistics. In face recognition tasks, important information may be contained in the high-order relationships among pixels, so that better basis images may be found by methods sensitive to these high-order statistics. ICA minimizes both second-order and higher-order dependencies in the input data. It provides a more powerful data representation than PCA as its goal to providing independent rather than uncorrelated image decomposition and representation [14].

It is good to find some independent components having less sensitivity under face verifications like: facial expressions, occlusion, and pose [12]. Briefly say, the goal of ICA is to provide a statistically independent decomposition of the data by considering higher order statistics of the training set using a linear transformation [23]. A new face image acquisition system and multi-views face database are proposed by Xudong et al [24], they evaluated and compared the performance of ICA

with PCA. The ICA experimental results were more efficient than PCA especially in face images with different orientations.

## 4.2 Neural networks (NNs)

Neural network is one of many approaches that have been used for extracting meaningful features. Artificial neural networks are widely used in face recognition system as a classifier whereas PCA and other linear discriminate approaches are used as features extractors. The multilayered neural networks combines three architectural concepts: local receptive fields, shared weights, and spatial sub sampling to satisfy some level of shift, scale, and distortion invariance. This kind of NNs is applied in many difficult applications such as: handwriting recognition, face recognition, and machine printed character recognition. Recently face recognition approaches focus on the representation and recognition concept, whereas the earlier methods consider the face recognition as standard pattern recognition problem. Artificial Neural Network (ANN) is presented in [25] as a face recognition and verification system that focus in both representation and recognition using artificial neural networks. The proposed system consists of two tasks: face-verification and face-recognition. In face recognition, the system has to decide which of the images stored in a database resembles to the image to recognize (one-to-many relation). In face verification, the system has already the identity of the user and has to verify this identity only (one-to-one relation). A face recognition system based on probabilistic decision-based NN (PDBNN) is proposed by [26]. It consists of three modules: a face detector, eye localizer, and face recognizer. The system performs human face detections, eye localization, and face recognition in close to real time speed. A novel face detection approach based on a convolutional neural architecture is presented by Christophe Garcia et al [9]. The approach was designed to detect face patterns of variable size and appearance in precise manner.

## 4.3 Fisherfaces

Linear Discriminate Analysis (LDA) and the related Fisher's Linear Discriminate are methods used in statistics and machine learning to find the linear combination of features which best separate two or more classes of objects or events. LDA is closely related to PCA, the factor analysis in that both look for linear combinations of variables which best explain the data. LDA explicitly attempts to model the difference between the classes of data. PCA on the other hand does not take into account any difference in class, and factor analysis builds the feature combinations based on differences rather than similarities. In computer vision face recognition application, each face is represented by an array of pixel values. LDA analysis is primarily used here to reduce the number of features before classification. Each of the new dimensions is a linear combination of pixel values, which form a template. The linear combinations obtained using Fisher's linear discriminate are called Fisherfaces. A 3D morphable model example is proposed by XIAO-MING [27] to Extend Fisherface method to drive multiple images of face from one single image.

Experimental results show that this method gives more impressive performance compared with conventional Eigenface method. Fisher LDA method is applied by [28] for a certain kind of cohesion when face overlap/coverage by different people. A combination of surface matching followed by PCA and LDA is proposed by Wei Jen Chew [29] to determine the identity of the unknown face. It is managed to produce good results and higher recognition rates to multi-view and surface matching method.

## 4.4 Laplacianfaces

Laplacianfaces is a recent linear technique for face representation and recognition. It is based on locality preserving projection and explicitly considers the manifold structure of the face space. Different from PCA, the LDA can effectively see only the Euclidian structure of face space; Locality Preserving Projections (LPP) obtains a face subspace that best detects the essential face manifold structure. An appearance-based face recognition method called the Laplacianface approach is proposed by Xiaofei He et al [15]. The undesirable variations of lighting, facial expression, and pose can be eliminated or reduced.

The experimental results on three different face datasets suggest that the proposed approach provides a better representation and achieves lower error rates in face recognition. The large size of face image makes Laplacianfaces approach projects the image vector to PCA to avoid the singular problem. The model proposed in [16] applied Local Feature Analysis (LFA) instead of PCA because of its capability to capture the local characteristic with less loss of global information. A different face recognition proposal method called the Laplacian Nonnegative Matrix Factorization (NMF) is proposed by TAI-PING ZHANG et al [17]. A Laplacianfaces has been incorporated inside the NMF to extend the NMF for extracting the discriminate information. They applied their proposal face recognition on Yale database. The experimental results show that the proposed approach achieves better face recognition performance than Eigenfaces, Fisherfaces, Laplacianfaces and NMF. A new feature extraction proposed in [30] and [31], for Two Dimensional Laplacian Eigen-Map (2DLEM) creates the proper features from image matrix directly by using a linear transformation. The disadvantage of image representation for many coefficients is overcome by proposing two-phase framework by [30]. Experiment on the ORL database show that 2DLEM achieves the best performance.

# 5 Face Databases

A standard database is used by researchers to test, evaluate and even compare their face recognition algorithm(s) results. An appropriate database is chosen based on the given task (aging, expressions, lighting, gender etc). Sometimes a specific dataset is chosen to test the algorithm(s) behavior with some conditions (e.g.; images with different facial expressions). Table. 1 lists most popular and recent publicly databases for face detection face recognition, and facial expression analysis [32]- [39].

Table 1, common face databases, their objectives, and applied methods

| Face Database | Objective(s) | Applied in |
|---|---|---|
| Color FERET, USA: | 1. The database is used to develop, test, and evaluate face detection and recognition algorithms<br>2. Allow a direct comparison between different algorithms,<br>3. Identify the most promising approaches,<br>4. Assess the state of the art in face recognition,<br>5. Identify future directions of research | 2D log Gabor Wavelet, Active Appearance Model(AAM), skin Gaussian model, Eigenface, SVM |
| Yale B: | Allows a systematic testing of face recognition algorithms under large variations in illuminations and pose | PCA, LDA |
| AT&T ORL: | Used in the context of a face detection and recognition project carried out in collaboration with the speech. | Eigenface, SVM, HMMs, Fisherface, NN |
| MIT/CMU: | Evaluates algorithms for detecting frontal views of human faces | Eigenface, NN, SVM |
| LFW-crop: | Used for a critical aspect dataset of training algorithm that runs mutually exclusive (pair matching). | PCA, ICA, LDA |
| Bosphorus: | Test the face recognition algorithms for 3D face data under various poses, expressions and occlusions | Generic transformation invariant 3D feature detector, PCA , LDA, |
| PUT: | provides credible data for systematic performance evaluation of face localization, feature extraction and recognition algorithms | |
| JAFFE: | Facial expression analysis | Gabor Wavelet, 2D Gabor Wavelet |

# 6 Conclusion

General Automatic Face Recognition System block diagram is proposed to illustrate the template database building phase and recognition/verification image processing phases. Many new approaches/methods for face recognition, verification, and representation system have been demonstrated, discussed and compared. The purpose of this paper is to explain the Automatic Face Recognition system phases, present the recent researchers approaches and trying to find the best effective approach that preserves our demands for robust face recognition/verification system.

We classified the approaches to modern and popular, although there are many classifications like; supervised and unsupervised approaches, statistical and structural approaches, geometric/image based techniques and feature based techniques. All approaches are selected from recent publications. Recent and popular face datasets is tabulated to assist the researchers how to find proper database in their applications.

# 6 References:


[1] Jin Young, Dae Young " Implementation and enhancement of GMM face recognition systems using flatness measure," in *Proc. of IEEE Int. Workshop, Kurashiki, Okayama Japan, Sep. 2004 Sep.*, pp. 20-22.

[2] Chu-Hong Hoi and Michal R. Lyu, "Robust face recognition using minimax probability machine," in *Conf. Rec. 2004 IEEE Int. Conf. on Multimedia and Expo.*

[3] Weihua Wang, WeiFu Wang, "A Gray-Scale face recognition approach," *in Second Int. Symposium on Intelligent Information Technology Application,* 2008, vol. 1, pp. 395-398.

[4] Jeff Keller, Tech. report, available, http:// www.dcresource.com/reviews/canon/powershot_s5-riview/

[5] Ming Zhao, Tat-Seng Chua, " Markovian mixture face recognition with discriminative face alignments," *in Conf. Rec. 2008 IEEE Int. Conf.*, pp. 1- 6.

[6] Sarat C. Dass, Anil K. Jain, Xiaoguang Lu, "Face detection and synthesis using Markov random field models," *in 16th Int. Conf. on Pattern Recognition (ICPR'02),* 2002, vol. 4, pp. 40201.

[7] Nhat Vo, Duc Vo, " Compressed sensing for face recognition," *IEEE Symposium Volume*, pp. 104 – 109, April 2009.

[8] Shang-Hung Lin, Sun-Yuan, "Face recognition/Detection by probabilistic decision-based neural network," *IEEE Trans. On Neural Networks*, vol. 8, no. 1, Jan. 1997.

[9] Christophe Garcia and Manolis Delakis, "Convolution face finder: A neural architecture for fast and robust face detection," *IEEE Trans. On Pattern Analysis And Machine Intelligence*, vol. 26, no. 11, Nov. 2004.

[10] JIA CUI, JIAN-PING, "Research on face recognition method based on cognitive mechanisim," *in IEEE Int. Conf.*, Dec.13-15 2008, pp. 62 – 65.

[11] N. Sudha, A.R. Mohan, "Hardware directed fast Eigenface based face detection algorithm using FFT," in *IEEE (ISIE 2009) Int. Conf.*, July 5-8, 2009.

[12] Lutz Goldman, Ullrich J. Monich, "Components and their topology for robust face detection in presence of partial occlusions," *IEEE Trans. On Information Forensics And Security*, vol. 2, no. 3, Sep. 2007.

[13] Chang Huang, Haizhou Ai, "High-performance rotation invariant multiview face detection", *IEEE Trans. On Pattern Analysis and Machine Intell.* , vol. 29, no. 4, April 2007.

[14] Qaiz Emad ul Haq, "Efficient and robust approach of Iris recognition through fisher linear discriminant analysis method and PCA method," *IEEE conference*, 23-24 Dec. 2008, pp. 218 – 225.

[15] Xiaofei He, Shuicheng Yan, "Face recognition using Laplacianfaces," *IEEE Trans. On Pattern Analysis And Machine Intelligence*, vol. 27, no. 3, March 2005.

[16] JiangFeng Chen, BaoZong Yuan, "Face manifold analysis based on LFA features," *Congress on Image and Signal Processing IEEE*, 2008

[17] TAI-PING ZHANG, BIN FANG, "Laplacianfaces incorporated inside nonnegative matrix factorization for face recognition," *Proc. of the 2007 Int. Conf. on Wavelet Analysis and Pattern Recognition, Beijing, China*, 2-4 Nov. 2007.

[18] Nasim Shams, Iraj Hosseini, "Low cost FPGA-based highly accurate face recognition system using combined Wavelets with subspace Methods," *in IEEE conference*, 8-11 Oct. 2006, pp. 2077 – 2080.

[19] Muthana Hamd, A. Bouzerdoum, "VHDL design for PCA", *Int. Conf. Computer design, CDES'08, Las Vegas*, July 14-17 2007.

[20] Behnam Karimi and Adam Krzyzak, " A study on significance of color in face recognition using several Eigenface algorithms," *IEEE Conference*, 22-26 April 2007 pp. 1309 – 1312.

[21] Nicolas Morizet, Federic Amiel, "A comparative implementation of PCA face recognition algorithm," *IEEE conference*, 11-14 Dec. 2007, pp. 865 – 868.

[22] Olivier de Vel and Stefan Aeberhard, "Line-Based face recognition under varying pose," *IEEE Trans. On Pattern Analysis and Machine Intelligence*, vol. 21, no. 10, Oct. 1999.

[23] Kazuhiro Hotta," Robust face detection under partial occlusion," *Systems And Computers in Japan*, pp. 39 - 48 vol. 38 , Issue 13, Nov. 2007.

[24] Xudong Jiang, "Asymmetric principle component and discriminant analyses for pattern classification," *IEEE Trans. On Pattern Analysis And Machine Intelligence*, vol. 31, no. 5, May 2009

[25] Zhiming Liu and Qingchuan Tao, "Face recognition using new image representation," *Proc. of Int. Joint Conf. On NNs*, Atlanta, Georgia, USA, June 14-19, 2009.

[26] Sharin Azuan Nazeer, Nazaruddin Omar and Marzuki Khalid, " Face recognition system using artificial neural networks approach," *IEEE-ICSCN 2007,* MIT Campus, Chennai, India, Feb. 22-24 2007, pp. 420-422.

[27] Xiao-Ming Bai, Bao-Cai Yin, "Face recognition Using fisherface with 3D Morphable model," *Proc. Of The 4th Int. Conf. on Machine Learning And Cybernetics*, Guangzhou, 18-21 Aug. 2005.

[28] Andy Adler and Michael E. Schuckers, "Comparing human and automatic face recognition performance," *IEEE Trans. On Systems*, vol. 37, no. 5, October 2007.

[29] Wei Jen Chew, Kah Phooi Seng, " New 3D matching technique for 3D model based face recognition," *Int. Symposium on Intelligent Signal, 2008.*

[30] Jiangfeng Chen, Baozong Yuan, Ming Liu, "Face recognition based On Two-Phase 2DLEM," *Proc. ICWMMN2006.*

[31] Jian-qiang Mei, Zheng-guang Liu, "*Application of Radial basis function network and locality preserving projections for face recognition*," 3rd Int. Conf. on Natural Computation (ICNC 2007).

[32] Ferdinando Samaria, Andy Harter, "Face datasets," *Proceedings of 2nd IEEE Workshop on Applications of Computer Vision, Sarasota FL,* December 1994

[33] A. S. Tolba, A.H. El-Baz, and A.A. El-Harby, "Face recognition: literature review,"*International Journal of Signal Processing* 2;2 © www.waset.org Spring 2006

[34] T. J. Cashman, "*Facial Feature Detection*," book, queens college, 16th May 2006

[35] *R. Singh, M. Vatsa and A. Noore, "Textural feature based face recognition for single training images,"* Electronic letters, 26th May 2005 Vol. 41 No. 11

[36] Chong Lu, Wanquan Liu and Senjian An, " Face recognition with only one training sample," *Proceedings of the 25th Chinese Control Conference* 7-11 Aug., 2006.

[37] Jin Young Kim, Dae Young Ko, "Implementation and enhancement of GMM face recognition systems using flatness measure," *Proceeding of IEEE Int. Workshop on Robot and Human Interactive Comm.,* Japan Sept. 20-22, 2004

[38] Kai-Ti, Yu-Ting Pai, "Exploring the tradeoff between power and detection rate for a face detection algorithm", *IEEE conference*, 25-27 May 2009, pp 3619 – 3622.

[39] C.C. Tsai, W.C. Cheng, "Face detection using Eigenface and neural network", *IEEE Inter.*

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