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Face Recognition Systems Using Different Algorithms: A Literature Review

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ABSTRACT

Background: As it has been an important device for various aspects in our life, face recognition became more developed, more widely used, and more needed to be highly accurate. Therefore, many researchers tried to use various algorithms (single or combined)to reach as better range of accuracy as they can**. Objective:** this paper aim to review of algorithms which was used for face recognitionin order to make a comparison between their function and outcome. **Results:** we shows the result of many technique by the proposed author's and explained the process of design face recognition system**. Conclusion:** a literature review of the most recent face recognition techniques was presented, with summary of its results.

INTRODUCTION

Face recognition has become an active area of research in computer vision, neuroscience, and biometrics since the last three decades. Face recognition is using for person authentication. Face also a part of human perception system capability. Every person has unique characteristics that not share with other's person (Umer *et al*., 2015). Its holds many advantages over different techniques for biometric; can catch appearances of individuals out in the open zones. (Dandashi and Karam, 2012). In order to produce a reliable system, a large database of facial images, a suitable algorithm and a testing procedure to evaluate the system are needed (Phillips *et al*., 2000). In this context of biometric techniques and modals, the face recognition technique arises to be the most researched one (Tan *et al*., 2006). Approaches to face recognition are the most used by humans to make a personal identification in many fields of life such as: criminals, terrorists, and missing children. It has become worldwide, especially in: Person identification (national IDs, Passports, voter registrations, driver licenses) (Shah *et al*., 2014), and automated identity verification (border controls). This area of research is promising for more development and more implementation in public sector such as security and surveillance (Woodward Jr *et al*., 2003), and in personal devices such as digital cameras, smartphones and laptops. Face biometric devices can be explained with a three-step procedure (Blackburn, 2001): (1) a sensor takes an observation. The type of sensor and its observation depend on the type of biometric devices used, (2) a computer algorithm "normalizes" the biometric face image so that it is in the same format (size, resolution, view, etc.), (3) a matcher compares the normalized images with the set (or sub-set) of normalized images on the system's database and provides a "similarity score" that compares the individual's normalized image with each image in the database set (or sub-set) (Tolba *et al*., 2006). However, because of the face recognition system use for security application, the accuracy become an important part of the system (Alobaidi *et al*., 2016). Recently a several methods have been designed for facial recognition. Some of these procedures depend on a lower

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dimensional space, or projecting the image, onto a transformed version (Alobaidi *et al*., 2016). Linear Discriminant Analysis (LDA) (Jiang *et al*., 2008; Moon *et al*., 2015), Principal Component Analysis (PCA) (Wang *et al*., 2015; Zeng *et al*., 2015). In Alobaidi *et al*. (2016) proposes a system for face recognition that uses both PCA and LDA. These algorithms were able to locate, normalize, and identify faces from a stored database. In the same context, many methods for evaluating the performance of these algorithms were used to achieve the final accuracy. The current review was therefore undertaken with the aim of identifying some of these algorithms and the results of their evaluation.

Background:

Most of the problems that Face Recognition suffered from are: variations in illumination, head rotation, facial expression, and aging. In order to solve these problems, researchers started to create and use several algorithms. In 1970's, Fischler and Elschanger (Fischler and Elschlager, 1973) tried to measure subjective features like ear protrusion, eyebrow weight or nose length by using an algorithm that used local template matching, and a global measure of fit to find and measure facial features. Kenade (Kanade, 1974) in 1973 designed and implemented a face recognition program ran in a computer system designed for this purpose. The algorithm extracted sixteen facial parameters automatically and compared to a human or manual extraction. He got a correct identification rate of 45-75%. He demonstrated that better results were obtained when irrelevant features were not used. In 1986, L. Sirovich and M. Kirby (Sirovich and Kirby, 1987) used a method which based on the Principal Component Analysis, and their work became the foundation of the proposal of many new face recognition algorithms. In 1992 Mathew Turk and Alex Pentland (Turk and Pentland, 1991) of the MIT presented an algorithm that was able to locate, track and classify a subject's head.

Method:

Engineering started to show interest in face recognition in the 1960's (De Carrera, 2010), and many documents have been published through the last years. The amount of published information is unmanageable for a short term effort, therefor this review focused on papers that met the criteria with respect to: types of studies, types of algorithms, types of outcome, and types of the final accuracy. Studies had to report empirical data-measuring about the accuracy of the outcome after using a specific algorithm. The main Data sources were Google scholar and Web of Science, and papers were restricted to the latest and most important used algorithms and the interpreted accuracy (success rate, false accepted rate and rejected rate) if any. The quality assessment for the types of papers included in the review depended on the Checklist for the Evaluation of Research Articles (Durant, 1994).

Face Recognition Algorithms:

Face recognition algorithms usually follow common steps: Firstly, some data dimension reduction and some pre-processing could also be done to adapt the input image to the algorithm prerequisites. Then, some algorithms analyze the image as it is, while others will extract certain relevant regions of the face. After that an extracting facial features or measurements will be processed. These will then be evaluated or compared to decide if there is a face and where is it, and the face will be recognized (De Carrera and Marques, 2010).

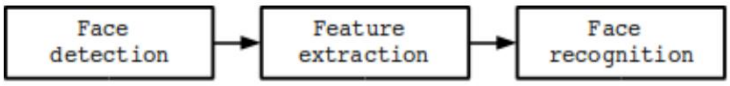

Fig. 1: Face recognition process.
Source: De Carrera and Marques (2010)

In general, face recognition algorithms can be classified according to the used approach:

1. Template based and geometry based approaches (Torres, 2004): The template based methods compare the input image with a set of templates (Jonsson *et al*., 2000), (Nain *et al*., 2008). The geometry feature-based methods analyze local facial features and their geometric relationships. There are algorithms developed using both approaches, such as a 3D morphable model approach combined with PCA to build a recognition system (Blanz and Vetter, 2003).
2. Piecemeal and Holistic approaches: in this approach the relation of a feature with the whole face is not taken into account (Brunelli and Poggio, 1993), and nowadays most algorithms follow a holistic approach.
3. Appearance-based and Model-based approaches: The representation of the face will be represented in terms of several basic intensity images, as in the appearance approach, or represented as a model of a human face in 2D or 3D, as in the model-based approach (X. Lu, 2003).

4. Template, statistical and neural network approaches: In template approach the face recognition is usually a correlation or distance measure, but in statistical approach it is a discriminant function. The attractiveness of using neural networks could be due to its non-linearity in the network (Lawrence *et al*., 1997).
5. Eigenfaces: is one of the most thoroughly investigated approaches to face recognition. Eigenfaces are the principal components of the distribution of faces, or the eigenvectors of the covariance matrix of the set of face images. Each face can be represented exactly by a linear combination of the eigenfaces. It can also be approximated using only the "best" eigenvectors with the largest eigenvalues (Sirovich and Kirby, 1987).
6. Graph matching: Object recognition can be formulated as elastic graph matching which is performed by stochastic optimization of a matching cost function (Lades *et al*., 1993).
7. Hidden Markov Models: This approach requires a one-dimensional observation sequence, therefore the two-dimensional of images should be converted into either 1D temporal sequences or 1D spatial sequence (Samaria and Fallside, 1993).
8. 3D Morphable Model: This model is based on a vector space representation of faces that is constructed such that any convex combination of shape and texture vectors of a set of examples describes a realistic human face (Vetter and Poggio, 1997).

From this review of approaches types, this paper endeavors to give a brief review about the statistical and neural network approaches, with results from previous research and their assessment.

Principal Component Analysis:

Principal Component Analysis (PCA) turns out to be one of the most successful techniques in face recognition systems as a statistical method for dimensionality reduction, but there is a problem related to accuracy and classification time. In their study Al-Arashi *et al*. (2014) tried to improve the system performance by associating a genetic algorithm (GA) to PCA to find the optimal underlying distribution of the training data, which is more suitable for classification. They found that accuracy and classification time are more superior compared to PCA if used by itself.

Table 1: Face recognition Accuracy and Time comparison.

	GA combined with PCA				PCA			
# of images per class k	# Training	# Eigenvectors	Accuracy %	Time (S)	# Eigenvectors	Accuracy %	Time (S)	RT%
3	30	20	91.7	0.0158	16	90.8	0.0194	18.51
6	75	22	96.0	0.0270	30	94.7	0.0432	37.50
8	70	10	100.0	0.0075	15	100.0	0.0184	59.23

Source: Al-Arashi.

Discrete Cosine Transform:

As it has a strong energy compaction properties, this statistical method is used to transform images, compacting the variations, allowing an effective dimensionality reduction. When a DCT is performed over an image, the energy is compacted in the upper-left corner. The DCT was categorized by Wang (1984) into four slightly different transformations named DCT-I, DCT-II, DCT-III, and DCT IV.

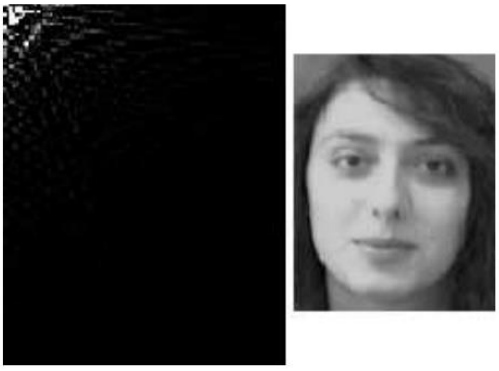

Fig. 2: Face recognition by using DCT method.
Source: De Carrera (2010).

The study of Hafed and Levine (2001) has discussed a face recognition system using the DCT, included both geometrical and illumination normalization techniques. They stated that the system was shown to perform very well when compared to other approaches. They claimed that a very high recognition rates can be achieved with a small increase in the number of face models per person, and they compared their results to the result of using a holistic approach called Karhunen-Loeve transform (KLT). Their recognition rate was 84.58% when they used 49 DCT coefficients for the feature vectors. They found that the optimum threshold for the distance measure between features would meet a particular system's performance criteria, and would give rise to 100% true positives (faces correctly accepted as known) and 0% false positives (faces incorrectly accepted as known).

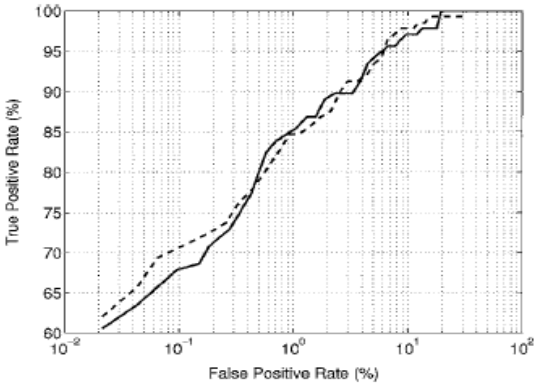

Fig. 3: Face recognition by using DCT method compared to KLT method (dashed line).
Source: Hafed (2001).

Linear Discriminant Analysis:

LDA is widely used to find linear combinations of features while modeling the differences between classes, and recently multi-class LDA algorithms which can manage more than two classes are more used.In the study of Murtaza *et al*. (2014) they defined two problems while using this method. Firstly, in training phase the number of samples in intra class is smaller than the dimensionality of the sample which makes LDA unstable. Secondly, the computational cost is high due to redundant and irrelevant data points in intra class. They suggested an Adaptive Margin Fisher's Criterion Linear Discriminant Analysis (AMFC-LDA) to overtake these problems, and they found that the proposed algorithm reveals encouraging performance. They made a comparison of recognition rate of different algorithms like PCA, LDA, D-LDA, RDA, LPP, MMC and ELDA with the proposed AMFC-LDA. The results are showed in table 2, where Ω denotes the random trained subset that shows the number of training sets, and the error rate is added or subtracted from the recognition rate according to realistic results.

Locality Preserving Projections:

It was introduced as an alternative to PCA, designed to preserve locality structure. This algorithm makes the recognition faster by making a search for the nearest pattern or neighbors.

Li *et al*. (2014) developed a novel face recognition algorithm (2D-DDLPP) which based on linear subspace Locality Preserving projection and discriminant analysis. Experimental results on the two well-known face image databases, ORL, and Yale, showed that 2D DDLPP is robust and more accurate than some other methods.

Table 2: A comparison of recognition rate of different algorithms.

	Ω =5	Ω =10	Ω =15	Ω =20
PCA	55.6 ± 3.0%	61.1 ± 1.9%	68.2 ± 1.4%	73.5 ± 1.2%
LDA	71.2 ± 1.9%	83.5 ± 1.5%	86.3 ± 1.2%	88.1 ± 0.6%
D-LDA	64.2 ± 1.8%	73.6 ± 0.9%	79.2 ± 1.6%	80.0 ± 1.2%
RDA	64.8 ± 2.1%	73.1 ± 1.1%	78.7 ± 1.3%	77.2 ± 1. 5%
LPP	65.8 ± 4.3%	78.4 ± 3.9%	82.7 ± 1.5%	83.2 ± 1. 9%
MMC	65.4 ± 2.5%	76.2 ± 1.2%	79.1 ± 1.8%	81.8 ± 1. 9%
ELDA	72.1 ± 2.3%	84.2 ± 1.5%	87.5 ± 1.7%	91.0 ± 1. 4%
AMFC-LDA	78.0 ± 1. 2%	89.38 ± 1. 5%	93.75 ± 1.0%	95.0 ± 1. 5%

Source: Murtaza (2014).

Table 3: The CPU time (S) consumed.

Algorithms	2DLPP	Discriminant 2DLPP	2D DDLPP
Training time(s)	3.8893	7.6585	7.9904

Source: Li (2014).

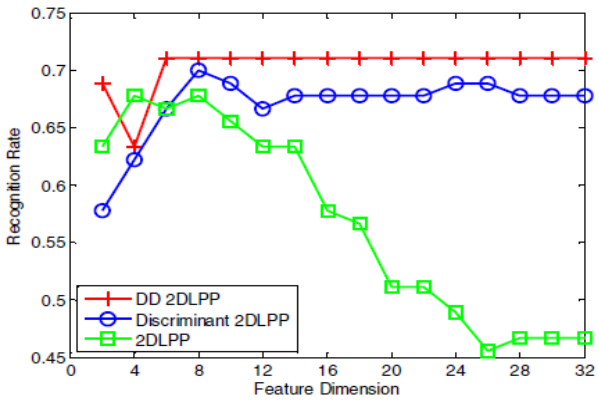

Fig. 4: Recognition rate over dimensions of feature vectors.
Source: Li (2014).

Table 4: Comparison of different approach in term of recognition rate.

Algorithms	Number of training samples per class					
	2	3	4	5	6	7
2DLPP(64 ×8)	0.3852	0.5583	0.5810	0.6556	0.7600	0.8167
Discriminant 2DLPP(64 ×8)	0.4148	0.6167	0.7048	0.6667	0.7467	0.8000
2D DDLPP(64 ×8)	0.5407	0.6833	0.7429	0.7111	0.7733	0.8167

Source: Li (2014)

Gabor Wavelet:

The Gabor functions are local spatial band-pass filters that achieve the theoretical limit for conjoint resolution of information in the 2D spatial and 2D Fourier domains. The image is represented in four dimensions, two are the spatial dimensions, and the other two represent spatial frequency structure and spatial relations or orientation.Cho *et al*. (2014) they proposed a flexible dual-stage algorithm that enables fast, hybrid face recognition, depending on DPL algorithm utilizes a PCA algorithm in the first stage and an LGBPHS (Local Gabor BinaryPattern Histogram Sequence) in the second stage. For the five used subsets, they got various results of recognition rate, and they used these results from subsets (2, 3 and 4) to compare between the suggested algorithms, as shown in table 5 and 6.

Table5: Number of images in each subset.

Subset 1	Subset 2	Subset 3	Subset 4	Subset 5	Total
263	456	455	526	714	2,414

Source: Cho (2014).

Table6: Average recognition rates and average computation times.

	PCA	LGBPHS	DPL6	DPL25
Average recognition rate	1413/1437 (98.3%)	1399/1437 (97.3%)	1426/1437 (99.2%)	1433/1437 (99.7%)
Average computation time (ms)	10	127,435	381	1,537

Source: Cho (2014).

Kernel pca:

This algorithm was used for performing nonlinear PCA by applying a non-linear mapping to the input, and then solves a linear PCA in the resulting feature subspace.Y. Lu *et al*. (2014) stated that The KLRC (Kernel Linear regression classification) approach achieved high recognition accuracy without preprocessing normalization steps. For comparison, they conduct on three standard databases (GT, FERET, AR) under some evaluation protocols. Results showed the difference in recognition rate between KPCA and KLRC (table. 7).

Table7: Recognition rate comparison (2014).

Method	KPCA	KLDA	SRC	LRC	KLRC
Recognition rate	0.7752	0.7863	0.8045	0.725	0.8266

Source: Lu.

Neural networks Algorithms:

There are several types of neural networks algorithms, which have been used as research tools in the field of face recognition.One of these algorithms was used with Gabor filters, where the main purpose was to overcome illumination variations, by implementing a multilayer perceptron with back-propagation algorithm. Each image is processed through a Gabor filter. The filter is represented as a complex sinusoidal signal modulated by a Gaussian kernel function. The output of the network is the number of images the system must recognize.Other neural network is connected with Hidden Markov Models, and according to Bevilacqua *et al*. (2008), this method showed promising results, achieving a 100% accuracy with ORL database.The last approach is Fuzzy neural networks, which has been developed by many researchers. One of the developed algorithms is the fuzzy multilayer perceptron, which was used to capture decision surfaces in non-linear manifolds. the developers Bhattacharjee *et al*. (2010) stated that results of the algorithm showed a 2.125 error rate using ORL database.

Other Algorithms:

Bayesian networks, bi-dimensional regression, genetic algorithms, ensemble-based and other boosting methods, are effective algorithms used by researchers in order to get better results in recognition rates and accuracy.

One of interesting research with interesting results is the work of (C. Lu and Tang (2014)). Their algorithm based on the Gaussian Processes (GPs) which is a non-parametric Bayesian kernel method. They named it "Gaussian Face" model, which was developed by including the multi-task learning constraint into Discriminative Gaussian Process Latent Variable Model (DGPLVM). They claimed their model can adapt to complex distributions, avoid over-fitting, exploit discriminative information, and take advantage of multiple source domains data. The source-domain datasets include five different types: LWF (Labeled Faces in the Wild), Multi-PIE, MORPH, Web Images and Life Photos (Figure. 5).The results showed that the Gaussian Face model, by an accuracy rate of 98.52% on the LWF, surpassed human-level performance in face verification of 97.53%, and this was achieved by exploiting additional data from multiple source-domains to improve the generalization performance of face verification in the target-domain and adapting automatically to complex face variations. The researchers made some comparison between existing methods, and results showed their algorithm achieving the best performance (Figure. 6).

Fig. 5: Samples of the datasets in our experiments. From left toright: LFW, Multi-PIE, MORPH, Web Images, and Life Photos.

Source: Lu and Tang (2014).

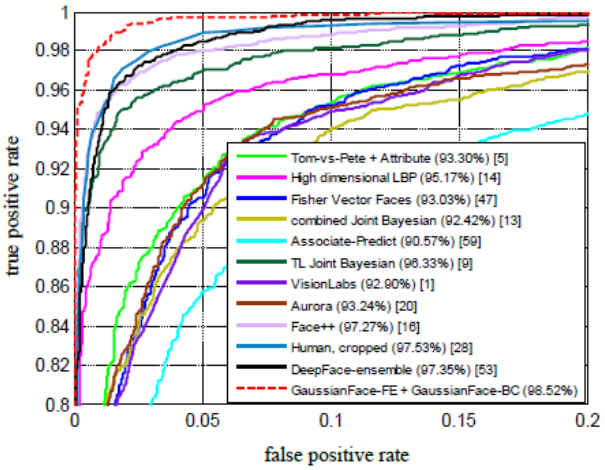

Fig. 6: The ROC curve on LFW dataset.
Source: Lu and Tang (2014).

Conclusion:

Face recognition is one of the most important issues which become interesting area for researchers. It is a challenging in the field of computer vision. Because of many algorithms used in different fields the face recognition has received great attention. This paper provided an up-to-date review of human face recognition algorithms. The algorithms Principal Component Analysis (PCA) is the most successful techniques in face recognition systems as a statistical method for dimensionality reduction, but there is a problem related to accuracy and classification time. LDA is widely used to find linear combinations of features while modeling the differences between classes, and recently multi-class LDA algorithms which can manage more than two classes are more used. DCT has a strong energy compaction properties, this statistical method is used to transform images, compacting the variations, allowing an effective dimensionality reduction. LPP designed to preserve locality structure. This algorithm makes the recognition faster by making a search for the nearest pattern or neighbors. The Gabor wavelet is local spatial band-pass filters that achieve the theoretical limit for conjoint resolution of information in the 2D spatial and 2D Fourier domains. Kernel PCA used for performing nonlinear PCA by applying a non-linear mapping to the input, and then solves a linear PCA in the resulting feature subspace. Gabor filters are types of neural networks algorithms, where the main purpose was to overcome illumination variations, by implementing a multilayer perceptron with back-propagation algorithm. Bayesian networks, bi-dimensional regression, genetic algorithms, ensemble-based and other boosting methods, are effective algorithms used by researchers in order to get better results in recognition rates and accuracy. The different face recognition algorithms are mentioned with summary of its results and the accuracy which achieved by researcher. This area of research is promising for more development and more implementation in public sector such as security and surveillance, and in personal devices such as digital cameras, smartphones and laptops.

Future Work:

Face recognition is one of the most common designed systems in authentication and identification of criminals and foreign objects. Developing an algorithm to work in reducing the complexity and increasing the accuracy rate of classifying peoples is a suggested to working in the futures.

Contribution:

This paper makes the following contributions:

- It evaluates the performance of many algorithms which worksto recognize the persons.
- It presents a literature review of face recognition which will give to the researchers a lot of the information.

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