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A Review paper on different Pose Invariant Face Recognition Techniques using Neural Networks

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Abstract— In existing face recognition techniques researchers have encountered major difficulties while dealing with variation of poses, aging, expressions, and variation in illumination. As the rotations of face parts causes major differences in face image and changes in appearance. For that reason extensive efforts have been taken by vision researchers in area of pose-invariant face recognition in last decade and many salient methodologies have been implemented. This paper provides a literature review of the existing robust face recognition methodologies using neural networks for handling pose invariant and above mentioned issues which caused difficulties in face recognition, it also contains detailed description of presented methods. This paper also includes strengths and drawbacks of these face recognition systems, and several promising directions for future research are also considered.

Keywords— Face recognition, Pose invariant, Gabor feature, local binary pattern (LBP), local derivative pattern (LDP) ,Neural networks, classifier.

I. INTRODUCTION

Human face recognition is still an on-going research area, it is a major research area of image processing and pattern recognition .In the last two decades researchers have shown significant diversion towards human face recognition because of its possible applications in security industry and human computer interaction systems. The purpose of face recognition is to correctly classify one or more persons from captured motionless images or video images of a scene by creating a database of these images for person verification. In our daily life human can remember many faces and can recognize them irrespective of illumination, aging, obstructions, variation in views. Most of researchers have worked on the problem of face recognition to develop an automatic face recognition system with capabilities to recognize faces as human beings can do. Researchers long ago during 1980 till 2005 have proposed a numerous of face recognition system but their main efforts are how to improve accuracy of system instead of improving the database used for identification, these system undergoes a performance drop with pose variations, varying illumination and changes in expressions as well, in some cases these system may fail to work.

Still existing face recognition systems needs improvement to deal with problems of aging, occlusions, variation in illumination and poses. As we know faces are highly deformable objects their appearance of faces varies over time period, either due to external and internal factors, applied that not all face areas are subject to the same variability. These situations make it difficult to solve the identification problem of an ill-posed face image. Most of the existing face recognition techniques (FRT) are able to perform very well in bounded environments, i.e. captured poses with strict constraints as defined in related face recognition standards. However, in unconstrained situations where a face may be captured in outdoor environmental conditions, while under changing illumination and pose variations these FRT fails to work, and this proves that their performances are constrained to the conditions of controlled environment, which is impractical in many real applications.

Face recognition across is of great interest in many face recognition applications, mainly those using unaccommodating subjects, such as surveillance systems. For example, in airport security system it is intending appealing to recognize terrorists. Airport security system keeps collection of images of faces of terrorists in the database will be compared against faces of traveler. While crossing every checkpoint of security system face of each individual will be scanned. If a match is found, cameras will be turned on to verify the match correctly and the system will decide whether to stop the individual whose face matches. A simple solution for this purpose is to collect images of each person in every pose to cover changes in face image at different poses. In order to implement robust face recognition systems this could perform well in uncontrolled environmental conditions, vision researchers have adapted and applied a numerous / an abundance of algorithms for classifying image , recognition and learning. To cope the problems of variation in poses , aging ,expressions, variation in illumination various curvelet and wavelet based feature extraction methods incorporated and to eliminate the problem of high data dimensionality PCA have been

successfully used, Principal Component Analysis (PCA) is a common statistical technique for finding the patterns in high dimensional data, to reduce dimension of the data to more tractable limits, to prominent features of the data and to eliminate redundancy.

One of the most significant step in face recognition is facial feature extraction, how to describe them, what features to use. There are two types of face image features local and global features. Global features are superiorly used in face recognition, but their performances decline with changes in poses, illumination as well as with different expressions of face. Most of the existing face recognition algorithms use the complete detected face to extract global features. But global features are sensitive to registration errors, occlusions and pose variations. Thus significant interest gained by local feature because of their robustness under changing poses and lightning and local features have now become superior in face recognition algorithms.

General procedure for Face recognition using neural classifier is as follows:

1) Image Pre-processing stage: Feature extraction of input image.

2) Dimensionality Reduction stage: high dimensional data reduction to a lower dimension to ease classification.

3) Classification stage: The reduced feature vectors are applied to train neural networks to recognize the image.

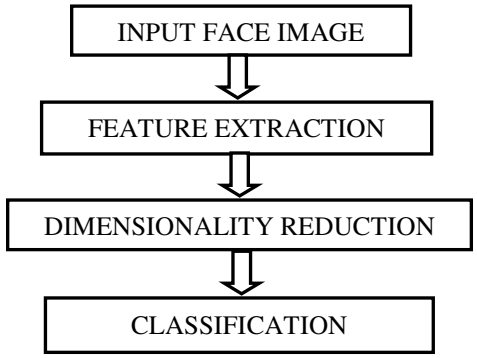

FIGURE 1: Block Diagram for face recognition

The considerable contribution of this paper is to present a comprehensive survey and review of current developments among robust methods of those pose invariant face recognition which recognizes the face image using neural networks. This paper mainly concerns on the discussions of existing methodologies for face recognition across pose, intend of providing assistance in technical understandings and promising directions to concerned researchers.

This paper is organized as follows: in Section 2 explains about the categorization of face recognition techniques based on feature extraction methods that are relevant. Section 3 provides a detailed review of recent developments in face recognition techniques under each category. Then summary in section 4, At last, conclusions are presented in Section 5.

II. PROBLEM DEFINATION AND CATEGORIZATION OF FACE RECOGNITION TECHNIQUES

Face recognition methods are classified as [1]:

1) Holistic approach: These approaches uses whole face image as the input to a face recognition system.
2) Feature-based approach: These approaches uses local features such as the eyes, nose and mouth are first extracted and their statistics are fed into a classifier.
3) Hybrid methods: Same as the human perception system, such methods uses both local features and the whole face region to recognize a face.

In this review paper, appearance based implementations of face recognition are categorized as, general algorithms; and 2D poses invariant techniques using neural networks. Those algorithms which do not contain specific approach to handle pose variations are classified as “general algorithms”.
They were designed for general purpose of face recognition equally handling all image variations.What is pose invariant in face recognition? Recognizing face across different poses or views refers to pose invariant in face recognition, pose variations caused challenges to recent developments in face recognition systems. Thus, a face recognition system is efficient if it has a good pose tolerance.

III. REPRESENTATIVE WORK OF VARIOUS FACE RECOGNITION TECHNIQUES THEIR ADVANTAGES AND LIMITATIONS

The Eigenface recognition method [2] is based on finding a set of basis images and represent faces as a linear combination of those images. By using Eigenface method sensitivity to noise is reduced. It gives, good performance under blurring, partial occlusion and changes in background, as PCA can reconstruct images in much better form than the original altered images in terms of their global appearance. The Eigenface method, which uses principal components analysis (PCA) for dimensionality reduction, provides those projection directions which maximizes the overall distribution across all images. In choosing the projection which maximizes total scatter, PCA retains unwanted variations due to lighting and facial expression [5]. As illustrated in Figure. 2 by Moses et al., “The changes between the images of the same person with varying illumination and pose are larger than those variations which are caused due to change in face Identity or different person image.

Figure 2: The same person seen under different lighting conditions can appear dramatically different: In the left image[5]

In method [2] by Turk et al. the basis images found by PCA depend only on pair wise relationships between pixels in the image database but relevant information may be present in the high-order relationships among pixels, so there is a possibility that better basis images may be found by techniques sensitive to these high-order statistics. Independent component analysis (ICA) [3], is one such method which is sensitive to high-order statistics. ICA was applied on face images in the FERET database and subjected to two different architectures, one which considered the images as random variables and the pixels as outcomes, and second architecture considered the pixels as random variables and the images as outcomes. The first architecture generated spatially local basis images. The second architecture produced a factorial face code. Both ICA representations were superior to representations based on PCA for identifying faces across days and changes in expression. A classifier which combined the two ICA representations gave the best performance.

Jahan et al.[5] have presented efficient technique to recognize faces using neural network (recognition classifier) on low resolution images. In this approach, they first pre-processed the original images by filtering and lighting normalization. The pre-processed image is given to neural network classifier as an input, neural network classifier uses back propagation algorithm to identify the known faces. But when this method is applied to FERET database the efficiency of degrades rigorously in the presence of pose variation. The proposed algorithm was trained on ORL (Olivetti Research Laboratory) database with 5 training images. The results provide the accuracy of 94.50%, 93.00% and 90.25% for 20, 30 and 40 subjects respectively.

Huang et al. [6] proposed a Support Vector Machine (SVM) based recognition system. Faces are decomposed into a set of components that are connected to each other by a flexible geometrical model. And any changes in the head pose causes changes in the position of components of face ,these changes could be accounted for by the adjustments in the geometrical model. In Huang experiments, the component-based system always superior in performance to global face recognition systems in which classification was based on the whole face pattern. By combining a 3D morphable model to each face image, the system eliminates the problems of pose and illumination variations. The 3D morphable model is used during training only, as while training slow speed and manual interaction is not a problem as in case of classification. This method achieved a recognition rate of 88% on a database of 2000 real imagesof ten people, which is significantly better than a comparable global face recognition system.

Bashyal et al. [11] developed an application using Gabor filter based feature extraction combining it with learning vector quantization (LVQ) for recognition of seven distinct facial expressions from still pictures of the human face. The results obtained by this application are much better in several aspects from the work exists in recognition of facial expression. In this technique feature extraction for face recognition and tracking using Gabor filter banks is reviewed to yield better results, so Gabor filters are applied to each of the images and filter responses are obtained only at predefined face points. In order to compare the efficiency of LVQ with that of MLP, the author considered same 34 fixed points on face which were used to obtain the Gabor filter bank response. Generalized accuracy of 87.51% is achieved for the entire JAFFE data set. This study indicates that the Japanese Female Facial Expression (JAFFE) database contains expressers that expressed expressions incorrectly and these incorrect images adversely affect the development of a reliable facial expression recognition system. The result obtained with this application is supporting enough to explore real-life applications of facial expression recognition in fields like surveillance and user mood observer.

Aroussi et al. [12] proposed an efficient local appearance feature extraction method based on Steerable Pyramid (S-P) wavelet transform for face recognition. In order to extract local information the statistics of each sub block is computed by dividing S-P sub-bands, for feature extraction mean, variance and entropy of each sub block is used. The obtained local features of each sub-band are combined at the feature level to increase performance of face recognition system. The purpose of this study is to learn and analyze the usefulness of S-P as feature extraction method for face recognition.

The author compared his approach with various feature extraction methods such as principal component analysis (PCA), as well as linear discriminant analysis LDA and

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boosted LDA. Different multi-resolution transforms, wavelet (DWT), gabor, curvelet and contourlet, are also compared against the block-based S-P method. Experimental results on ORL, Yale, Essex and FERET face databases shown that this method results in a better recognition accuracy in comparison to other holistic approaches.

IV. SUMMARY

The face recognition methods have been classified into two groups, general techniques that sensitive to pose variations, lightening, occlusions and other group includes those techniques which are robust and effectively handle pose variations. The methodologies of these techniques have been summarized in Table 1 and the advantages and limitations of different methods have been summarized in Table 2 and Table 3 respectively.

Table 1 :Categorization of face recognition techniques

Category	Methodology
General Algorithms	1.Principal-component analysis (PCA) Eigenfaces for recognition [2]. 2.Face Recognition by Independent Component Analysis[3]. 3. Artificial neural network (convolution networks[17]) 4.Face recognition using Local binary patterns [15]
Pose invariant face recognition Algorithms	1.Low Resolution Single Neural Network Based Face Recognition[5] 2.Component-based face recognition with 3D Morphable models[6] 3. Recognition of facial expressions using Gabor wavelets and learning vector quantization 4. Local appearance based face recognition method using block based steerable pyramid transform 5. Robust facial expression recognition using local binary patterns 6. Face recognition by elastic bunch graph matching 7. Face detection using Gabor wavelet and neural network

Faces composed of interconnected pixels which make it complex, multidimensional, purposeful visual information and it is not easy task to develop an automatic model for face recognition. In method [17] Lawrence et al. proposed a hybrid neural network solution, this study compared against other methods. This system combines sampled local image, a self-organizing map neural network, and a convolutional neural network. The map is used to provide a quantization of the distinct samples of image into a topological space and have been arranged in a way such that inputs that are nearby in the original space are placed nearby in the output space, in this way providing dimensionality reduction and to remain unaffected by minor changes in the sample of image, and the convolutional neural network is used to provide for partial invariance to the chamges caused by translation, rotation, scale, and deformation. The convolutional network extracts successively larger features. To reduce dimension of results, Karhunen-Lo` eve transform or PCA can be used in place of the self-organizing map, and a multi-layer perceptron in place of the convolutional network.

TABLE 2. VARIOUS FACE RECOGNITION TECHNIQUES AND THEIR REPRESENTATIVE WORK

Methodology	Representative work
1. Eigenfaces for Recognition [2].	Holistic approach using pixel intensity for feature extraction then dimensionality reduction with Principal component analysis (PCA) and classified using Nearest neighbor classifier.
2. ICA-based feature analysis [3]	Holistic approach which subjected to two different architectures, one which considered the images as random variables and the pixels as outcomes, and on other architecture considered the pixels as random variables and the images as outcomes.

4. Face recognition using Local binary patterns [2]	It considered both shape and texture information to represent the face images. The face area was first divided into small regions, LBP histogram of each region is extracted. The recognition is performed using a nearest neighbor classifier
5.Low Resolution Single Neural Network Based Face Recognition[6]	This approach involves two steps preprocessing and face classification. The reprocessed image becomes the input to neural network classifier, which uses backpropagation algorithm to recognize the familiar faces[5]
6.Component-based face recognition with 3D Morphable models [7]	pose and illumination invariant face recognition system that 3D morphable models and component based recognition. A 3D morphable model is used to compute 3D face models in the training database. These 3D models build a large set of synthetic images. These images are used for training a component-based face recognition system.
7.Recognition of facial expressions using Gabor wavelets and learning vector quantization[11]	This approach uses Gabor filter for feature extractions and PCA for lowering the dimensionality Linear vector quantization (LVQ) was used to classify the images.
8.Local appearance based face recognition method using block based steerable pyramid transform[12]	Local information is extracted by evaluating the statistics of each sub-block obtained by dividing S-P sub-bands. The obtained local features of each sub-band are combined at the feature level to enhance face recognition performance.

TABLE 3. VARIOUS FACE RECOGNITION TECHNIQUES AND THEIR ADVANTAGES IN TERMS OF POSE INVARIANCE, EFFICIENCY AND OTHER PROBLEMS

Methodology	Advantages
1. Eigenfaces for Recognition [2].	This method is fast, simple, and practical method. PCA is considered the most popular multivariate statistical technique to find useful image representations. Such representations reduces sensitivity to noise and gives good performance under blurring, partial occlusion and changes in background.
2. ICA-based feature analysis [3]	ICA is better than PCA , captures both second and higher order statistics and projects the input data onto the basis vectors that are as statistically independent
3. Two-dimensional PCA: a new approach to appearance-based face representation and recognition	This method uses directly 2D image matrices rather than 1D vectors for covariance matrix estimation as in PCA, it is mathematically cheap and simple, more suitable for small sample size approaches
4. Face recognition using Local binary patterns [2]	LBP features are robust to low-resolution images. This method is superior to PCA and elastic bunch graph matching.
5.Low Resolution Single Neural Network Based Face Recognition[6]	It uses single neural network as classifier,which produces straight -forward approach towards face recognition. It applies bi-cubic interpolation function on equalized image to get resized image which is low-resolution image thus providing faster processing for training and testing
6.Component-based face recognition with 3D Morphable models [7]	It is robust, accurate, and easily trainable face recognition system. The component-based system consistently outperformed global face recognition systems in which classification was based on the whole face pattern
7.Recognition of facial expressions using Gabor wavelets and learning vector quantization[11]	it is observed that LVQ based feature classification technique proposed in this study performs better in recognizing fear expressions than multilayer perceptron (MLP) based classification technique
8.Local appearance based face recognition using block based SP transform[12]	obtains much higher recognition accuracies in real-world situations including changes in pose, expression and illumination

TABLE 4. VARIOUS FACE RECOGNITION TECHNIQUES AND THEIR LIMITATIONS

Methodology	Limitations
1. Eigenfaces for Recognition [2].	This approach sensitive to large variation in lighting direction and facial expression. The changes between the images of the same person with varying illumination and viewing direction or pose as well are always more than those variations in image which caused due to change in face Identity.
2. Face recognition using Local binary patterns [2]	this approach lies in the length of the feature vector which makes the recognition process very slow
3.Low Resolution Single Neural Network Based Face Recognition[6]	Its efficiency degrades extremely in the presence of pose variation in the case of FERET database
4.Recognition of facial expressions using Gabor wavelets and learning vector quantization[11]	This approach has high time complexity
5.Local appearance based face recognition method using block based steerable pyramid transform[12]	It was inefficient in terms of time complexity for larger dataset

V. CONCLUSION

As the striking problem in face recognition, pose variation gained major attentions in the research area of image processing, pattern recognition and computer vision. A number of likely techniques have been implemented to bear and compensate changes in image caused by pose changes. However, attaining pose invariance in face recognition still remains a challenge not resolved completely, it requires consistent attentions and efforts to accomplish pose invariance. This paper first considered those techniques, providing a literature survey and discussions on major problems eliminated each approach and possible future research directions towards pose-invariant face recognition. In this paper firstly discussed the problem encountered by various face recognition techniques (FRT), with discussions on the challenges, recent existing evaluation methodologies, and efficiency of different approaches. Face recognition methodologies were then classified into two categories one is "general algorithms" and other is " pose invariant techniques". Those algorithms which do not contain specific approach to handle pose variations are classified as "general algorithms". They were designed for general purpose of face recognition equally handling all image variations, thus general algorithms studies have been reviewed focusing on their sensitivities to pose variations. The other category techniques which actively handle pose variations have been comprehensively reviewed in the sections with discussions on their advantages and limitations. By reviewing various pose invariant technique it is observed that for face recognition, feature extraction is most crucial step ,thus use of multi-resolution and multi-orientation Gabor decomposition for feature extraction yields better results, still the problem of pose variation is not completely eliminated, also face recognition research requires development of such a system concerning effectiveness and robustness of system to the slight variations of lighting, expression, and pose. Future efforts will be focused on expression recognition, especially for pose and occlusion variations in unconstrained environment.

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