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Review on Facial Expression Recognition Techniques

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Abstract— Face Expression Recognition (FER) has turned into an extremely interesting and challenging area in computer vision field due to its wide application potential outcomes. Mental states Recognition, Human Computer Interaction, Human behavior understanding etc. are some of its applications,because of its wide application possibilities. The facial expression recognition finds major application in areas like social interaction and social intelligence. This review paper present various techniques used in facial expression recognition like principal component analysis (PCA), linear discriminate analysis (LDA) etc is done in this paper. The survey is represented in tabular form for quick reference.

Keywords— Face Expression Recognition, Feature Extraction, Automatic facial expression recognition.

INTRODUCTION : Face Recognition has been one of the major area of interest in the field of biometric and security for the past few decades. Humans have a very strong face recognition technique. Human brain is so sophisticated that it can recognize faces even with the vast changes in appearance. The scientists have always been amazed by the human brain capacity to recognize face under different varied condition. A lot of attempt were made to replicate this technique of our brain. Various algorithms were developed for face recognition based on this. The efficiency of recognition depends on feature extraction method adopted. Evolutionary algorithms like neural networks, fuzzy logic etc. were also incorporated with the face recognition algorithms to increase the recognition rate. But there are a lot of constraints that has been implemented in applying these algorithms, like the poses should not vary, or there should not be any difference in the illumination, the expressions should not vary, there should not be much changes with age etc. Overcoming even a single constraint is a great challenge. The facial expression recognition systems consists of four major steps. Face detection and normalization phase detects the face and lighting effect is reduced. Next step is feature extraction which extracts the features and irrelevant features are eliminated in feature selection process. Final step is classification where the expressions are classified in to six basic emotions.

Facial expression recognition methods are separated into two categories: geometric-based methods and appearance-based methods. Geometric-based methods concern about the feature vectors encoding some facial geometric properties such as distance, angle, and position to determine the shapes and locations of the invariance points of face. For instance, in invariance points belong to a face image were extracted for facial expression recognition. 20 invariance points were derived from 74 separate landmarks in. Success of the methods depends on powerful face component detection methods to set facial invariance points, which provides a few difficult at real life applications. Appearance-based methods use the features extracted directly from the images but does not include an information relating to the facial points. There are a lot of Appearance based methods. The most important ones are Local Binary Pattern (LBP), Gabor Wavelets,Local Gabor Binary Patterns (LGBP), Scale Invariant Feature Transform (SIFT), Histogram of Oriented Gradient (HOG), and Curvelet Transform. Facial expressions make the certain regions of face change, which causes interest in just the special regions. In, the salient features were extracted from local patches.

Techniques for Facial Expression Recognition

A. **Principal Component Analysis**
Principal Component Analysis (PCA), also known as the eigen face approach is one of the popular method for facial expression recognition. The major goal of PCA is to reduce the dimensionality for effective face indexing and retrieval. Also, PCA uses linear projection, which maximize the projected sample scattering. In this, the identity of the person is the only varying factor.PCA faces difficulty if other factors like viewpoint, lighting are varied.

B. Fisher's Linear Discriminant

Under severe variation in facial expression and illumination Fisher‟s Linear Discriminant (FLD) is more suitable. FLD reduces the scattering of projected sample since it is a class specific method. Error rate is reduced when compared to PCA.

C. Independent Component Analysis

Both PCA and LDA generate spatially global feature vectors. But for effective facial expression recognition spatially localized feature vectors is needed. Therefore Independent Component Analysis (ICA) generates statistically independent basis vector. The average recognition rate is improved. But ICA is computationally expensive than PCA.

D. 2Dimensional Principal Component Analysis

In PCA, feature extraction is done based on 1D vectors. Therefore the image matrix need to be transformed into vector. 2dimensional Principal Component Analysis (2DPCA) uses 2D matrix instead of 1D vector. The recognition rate of 2DPCA is higher than PCA. But the storage requirement for 2DPCA is higher than PCA since 2DPCA needs more coefficients for image representation.

E. Global Eigen Approach using Color Images

Conventional facial expression recognition techniques like PCA, LDA etc uses only the luminance information in face images. Global Eigen Approach uses the color information in face images.RGB color space does not provide any improvement in recognition rate. In HSV color space, H component is removed since it reduces recognition rate. YUV color space provides high recognition rate.

F. Sub pattern Extended 2-Dimensional PCA

The recognition rate of PCA is low and has small sample size problem. For gray facial expression recognition, 2DPCA is extended to Extended 2DPCA. But E2DPCA is not applicable for color images. Therefore Sub pattern Extended 2-Dimensional PCA (SpE2DPCA) is introduced for color face recognition. The recognition rate is higher than PCA, 2DPCA, E2DPCA and problem of small sample size in PCA is also eliminated.

G. Multilinear Image Analysis

Facial expression recognition needs different factors like pose, lighting, expressions to be considered. But the conventional PCA addresses only variations in single factor. Multilinear image analysis use multilinear algebra. In this, the concept of „Tensor faces‟ is used, which separates different factors underlying the formation of an image. Recognition rate is greater when compared to PCA approach. Color information is not incorporated in multilinear image analysis.

H. Color Subspace Linear Discriminant Analysis

The 1DLDA AND 2DLDA are extended in color space to improve the face recognition accuracy. A 3D color tensor is used to generate color LDA subspace. Horizontal unfolding increases the recognition rate for 2DLDA while vertical unfolding improves recognition rate for 2DPCA.The performance evaluation of various color spaces is not done.

I. 2D Gabor filter bank

The Gabor filtering is considered as one of the most important feature extraction technique in facial expression recognition. Gabor filter bank performs better in terms of recognition rate than the other methods like PCA, LDA etc. The major limitation of gabor filter is its bandwidth limitation ie. maximum bandwidth is limited to one octave. Gabor filters loss high and low frequency information since it is band pass in nature

J. Local Gabor Binary Pattern

Appearence based features are being used for face recognition since it encodes specific details about human faces. In this facial image is divided into sub blocks and similarities between sub blocks is obtained. An important advantage of Local Binary Pattern (LBP) is its illumination tolerance. In Local Gabor Binary

Pattern(LGBP) method, LBP is extracted from gabor filters for feature vector generation. LGBP achieves better performance than gabor filter method.

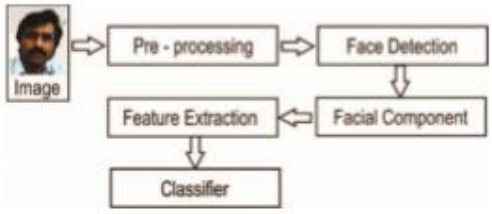

Fig. 1. Steps in Face Expression Recognition

The Face Expression Recognition is a multistage process. i.e. it is processed in stages. The main stages of FER are (1) Preprocessing (2) Face Detection (3) Facial component Detection (4)Feature Extraction and (5) classification.

Table 1. Literature Survey Of Different Methods Of Face Expression Recognition

SLNo.	Method/Technique(s)/ Database	Result/ Accuracy	Conclusion	Future scope
1	Curvelet Feature Extraction	The FER is carried out on JAFFE database. The recognition rate was 94.74% (72/76)	This paper introduced curvelet transform for addressing the FER.	Combination of curvelet transform with other dimensionality reduction method like ICA, LLE etc.
2	Expression invariant 3D Face Recognition using Patched Geodesic Texture Transform	The experiments were conducted on BU-3DFE. The algorithm was tested with 6 expressions. Disgust has the lowest recognition rate 78% and anger has maximum (90%)	PGTT can be used for expression invariant face recognition. It gives superior results.	
3	FER based on Bag of words Method Considering Holistic and Local Image Features	Facial expression Recognition rate is 96.33% on Cohn-Kanade database	This method can give excellent face recognition performance under various conditions including extreme expressions, strong non uniform lighting and partial occlusions.	
4	Local Directional Number Pattern for Face Analysis: Face and Expression Recognition	The proposed method was tested with five different databases: CK, CK+, JAFFE, MMI and CMU-PIE. AN average of 94.4% accuracy was obtained	The proposed method was found to be very robust and reliable under various expressions, time lapse and illumination variations.	
5	Regional Registration for Expression Resistant 3D Face Recognition	An accuracy of 97.51% is achieved for FRGCv2 database. The recognition rate in Bosphorus database is 98.19%.	A fully automatic Expression insensitive 3D face recognition system was proposed by the authors. The identity of the person is infered by using the facial surfce characteristics	Future studies must investigate aggregation of data from different sensors
6	FARO: Face Recognition Against Occlusions and Expression Variations	FARO was tested with the presence of illumination variations, changes in expressions and also partial occlusions. AR Database was used for the experiments.	FARO is robust to presence of both natural and synthetic occlusions like scrafs, sunglasses etc.	As a future scope eyebrows can also be included which will increase the accuracy of the system. Also the basic PIFS method can be modified for getting better results.
7	Gradient Feature Matching for Expression Invariant Face Recognition using Single Reference Image.	Proposed method gave a recognition rate of 94% in the Yale database, 99.52% in JAFFE database and 100% in the CMU AMP database.	The proposed method was found to be independent of expression variations and gave a very good result when applied on Yale, JAFFE and CMU AMP databases.	The future scope includes the testing of the proposed method on larger databases like CK+ and AR databases.
8	A design for Integrated Face and Facial Expression Recognition	A High Recognition rate of 98.3% was obtained when conducting experiments on BU-3DFE database. The proposed method gave a face expression recognition rate of 83.8% in the integrated method.	An integrated face and face expression recognition system with high recognition rate was introduced. It is a two stage process. In the first stage users face is recognized and facial expression is recognised by using his/her personal expression database	The authors are planning to implement this method on an interactive service

Table2: Comparison table on literature survey

NAME	METHOD	PERFORMANCE	DISADVANTAGES
Low-Dimensional Procedure for Characterization of Human Faces	Principal Component Analysis	Recognition rate is low	Only single factor can be varied
Eigenfaces vs. Fisherfaces : recognition using class specific linear Projection	Fisher's Linear Discriminant	Recognition rate higher than PCA	Global feature vectors are generated
Recognizing Faces with PCA and ICA	Independent Component Analysis	Recognition rate is improved compared to PCA and FLD	Computationally expensive than PCA
Two-dimensional PCA: A new approach to appearance-based face representation and recognition	2-Dimensional Principal Component Analysis	Recognition rate is higher than PCA	Storage requirement is higher than PCA
The importance of the color information in face recognition	Global Eigen Approach using Color Images	YUV color space has highest recognition rate	RGB color space does not provide any improvement in recognition rate
A novel hybrid approach based on sub-pattern technique and E2DPCA for color face recognition	Subpattern Extended 2-Dimensional Principal Component Analysis	Recognition rate higher than PCA,2DPCA	Variation in lighting, pose are not considered
Face Recognition using a Color Subspace LDA approach	Color Subspace Linear Discriminant Analysis	Recognition rate is higher than 2DPCA and LDA	Variation of performance in color spaces is not evaluated
Multilinear Image Analysis for Facial Recognition	Multilinear Image Analysis	Recognition rate higher than PCA	Less performance than Color Subspace LDA
Gabor Filter Based Face Recognition Technique	2-Dimensional Gabor Filter Bank	Higher recognition rate than PCA, LDA,2DPCA,Global Eigen Approach	Low and high frequency component attenuation
Local binary patterns for multi-view facial expression recognition	Local Gabor Binary Pattern	Better recognition rate than Gabor filter bank	Color information is not included

illumination conditions and thus performance can be improved.

CONCLUSION

This paper presents a literature survey on the various techniques involved in facial expression recognition. There are various techniques that can be used for the purpose. These methods are measured on the basis of recognition rate. Higher the recognition rate, greater the performance. The tensor perceptual color framework has the highest recognition rate and has highest performance.

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