Comparative study of different types of Feature Extraction algorithms and Classifiers used in FER System

Trina Das, Shamneesh Sharma

Abstract— ***The computerized identification and classification of the facial expressions has been an investigative field from very beginning. Being a major approach of emotion detection, the automatic recognition of Facial Expression has been one of the latest research topics within various fields such as computer vision, medicine and psychology since 1990's. The ideal facial expression recognition is still a confront for a machine or computers. A numerous number of research efforts and techniques have been made in the field of facial expression recognition from still pictures and live videos. Despite of important advances, it also has some defies. This paper includes an overview of facial expression recognition techniques, related issues and few published and reviewed papers on emotion detection are summarized here briefly.***

Keywords: - Face Recognition, Global and Local feature, Feature Extraction algorithm, Classifier, FER dataset.

1. INTRODUCTION

Affective computing can be defined as the analysis and evolution of machine that can exhibit human emotions. From a perspective of human-machine interaction, affective computing's most important topic is automatic emotion detection, analysis and recognition. Identifying information related to human emotions need the extraction of patterns from the gathered data in a meaningful way. It can be done with the help of machine learning algorithms that recognizes different human faculties such as speech, natural language or facial expression, and produce either label (i.e. 'confused') or coordinates in a valence-arousal space. The muscular motion in a single or multiple instances beneath the skin is generally known as the Facial Expression. Ongoing psychological research has demonstrated that facial expressions are the foremost expressive way in which humans show feelings. As per Mehrabian [1] 7% effect of the message is contributed through verbal part, while 38% is contributed by vocal part and 55% is contributed with facial expression. An effective increase in the use of biometric modalities can be seen in our day to day lives. It can be seen in our phones, metro railway systems and even in offices for attendance purposes. Further extension of the use of biometric modalities can be seen in the cloud computing platforms used in the public and private proposals like Electronic version of passports, Banking authentication systems, election administration and many more [2]. The use of face recognition techniques at the place of other biometric systems and modalities has numerous numbers of advantages due to its various properties like natural, non intrusive, separate capturing or scanning techniques undercover ways [3].

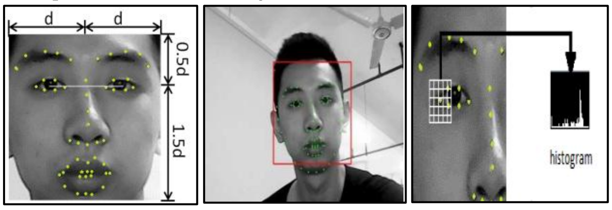

**Figure No. 1 (a) Results of landmark detect,
(b) Result of face normalize
(c) calculating histogram for a landmark point**

Face Recognition System: The formulation of the general statement of automatic face recognition predicament can be defined as follows [4]:

- Specified stagnant or motion pictures of a panorama
- With the use of stored database of faces, the identification and substantiation of more than one person in a panorama

The resolution of this predicament comprises of three foremost undertakings as given below [5]:

- Face recognition from a outlook
- Feature extraction and illustration of the facial province or region.
- Face comparison and classification.

The first undertaking includes the face edge detection, segmentation and localization whereas the second one includes stuffing, dimension diminution, and noise extraction. The third approach includes various classification techniques. Among these tasks Feature extraction is very crucial since using inadequate features (even in conjunction with the best classifier) may lead to the failure of accurate recognition.

Feature Type:

There are two categories of features, one is local and other is global feature. Local features refer to the geometric modalities of the face on the other hand global feature relates the topological sphere of the face. Using local feature Gao Xiang [6] introduced an approach which utilized familiar sights for the normalization of the facial representations. The author of [6] has also use the described technique to decrease the dimensions of LBP Histogram by computing the LBPH of facial features.

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Trina Das, M. Tech Scholar, Department of Computer Science & Engineering, Alakh Prakash Goyal Shimla University, Shimla, H.P, India.(E-Mail: das1990trina@gmail.com)

Shamneesh Sharma, Head, Division of Information Technology & Associate Professor, Department of Computer Science & Engineering, Alakh Prakash Goyal Shimla University, Shimla, H.P, India. (E-Mail: shamneesh.sharma@gmail.com)

Using familiar sight modalities the key points of facial features can be computed. These key points are called minutia which can be used for the calculation of facial expressions instead of using whole picture. Sometime this technique may lead to lose some features.

In contrast Jingjing Wang [7] introduced a concept of the discriminant ability to get freed of superfluous information and in the meantime decrease computational burden. The Artificial Neural Networks (ANN) can be used as individual classifiers to compute the Global Optimal Discernment Features by using the Genetic algorithms. These computed classifiers can be merged together with base classifiers. There is one recommendation from many researchers of this field for better classifier assembly is to use the diverse features for the construction of combined classifiers. The equation no. 1 shows the Classifier Construction using the Exploratory Data Analysis.

$$E_{vi} = sgn(\prod_{x=1}^{M}(\sum_{y=1}^{R} p_{ij}))\sum_{j=1}^{K} p_{ij} * classifier_j$$

(Equation No. 1)

Hence, in [8] this article, Yuan Luo introduced a hybrid method of PCA and LBP where LBP extracts the local grayscale attributes for the support of comprehensive grayscale attributes of face appearance identification since grayscale images are subject to the environment and this method achieved a higher recognition rate than using PCA only. It is implemented by defining the covariance matrix, a corresponding Eigen face based feature and LBP code respectively as follows:

$$\varphi = \frac{1}{N}\sum_{s=1}^{N} XX^T$$

(Equation No. 2)

Where, $X = [\ \xi_{11} - \overline{\xi},\ \ \xi_{12} - \overline{\xi},\ \ldots\ldots,\ \xi_{ij} - \overline{\xi}]$, and $\overline{\xi} = (1/N)\sum_{i=0}^{C}\sum_{j=0}^{M}\xi_{ij}$ Image Training Set Mean

$Y_k = P^T \zeta_k$, where, k = 1,2,3,…….., N

(Equation No. 3)

Where ζ_k is the mean image subtracted from X_k.

LBP $(x_c, y_c) = \sum_{i=0}^{7} s(g_i - g_c)2^i$

(Equation No. 4)

The Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) covers the comprehensive composition of the Euclidean space whereas Linear Regression Classification (LRC) covers the partial composition of the appearance. These three components of facial recognition techniques are considered in the category of Linear Subspace Learning Algorithms. The Linear Subspace Learning Algorithms are not able to recognize the face expressions with excess of variations in case of elucidation circumstances. Non-linear extensions have been found helpful when dealing with such cases but these extensions have a theoretical base only which leads to fail in the practical implementations in the face detection techniques. So PCA, LDA and LRC methods are used in most of the face recognition techniques. The extension of non-linear functions can be seen in the Gabor Wavelets and Artificial Neural Networks (ANN).

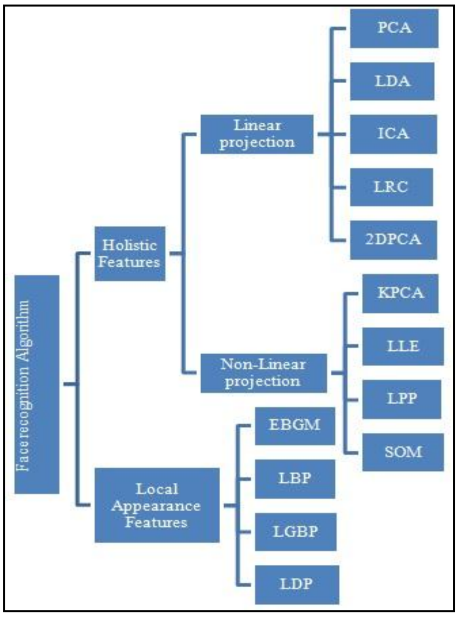

Figure No. 2 Face Recognition Algorithm

In the Gabor Wavelets the Gaussian Function is used with plane waves.

The confined manifestation attributes have few benefits over holistic attributes which leads to a more venerable use of these the local changes. After the development of picture descriptors that can enhance classification execution of multi-choice recognition and combine coordinating of face pictures are examined in the literature [9] and [10]. For the face detection and recantation the next technique is 3 Dimensional geometrical techniques. The benefits of using 3 Dimensional data is that profundity records does not rely upon the posture and elucidation, moreover in this manner the portrayal of the entity does not alter with the described parameters. The author of [11] has also contributed that the 3 dimensional techniques are a common answer to the posture disparity issues. If there are some benefits, there are some disadvantages too with 3 dimensional techniques which can be the requirement of all the precise data of coordinates related to face. The 3 dimensional techniques are based on the complicated feature extraction and matching algorithms which are expansive and unsuitable for practical implementations. Furthermore, the volume of biometric modalities has been increased in the examination of facial picture data managed in video streams [12]. An instantaneous benefit of using the information gathered from the video streams is the likelihood of utilizing excess display within the video grouping to improve still picture frameworks. Although some noteworthy researches have been done in the field of matching the still faces representation and use of video streams for face identification is comparatively not discovered more [13].

Feature Extraction Approach:

There are mainly two methods in feature extraction of facial expressions one is based on geometric feature and other is on appearance.

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The first approach considers the silhouette and location of the various parts of the face and develops a correlation between the components for the construction of attribute or feature vector [14] while second approach applies and validates the filter banks on entire face area as Principal Component Analysis [8] and Gabor Wavelet [15]. According to Valstar et al. [16, 17] demonstration, the Geometric Attribute Based Approaches (GABA) endow with the analogous execution than Manifestation Based Approaches (MBA). In any case, Geometric Attribute Based Approaches (GABA) generally necessitates precise and dependable facial component identification and following, but is troublesome to oblige many situations. On the other hand Manifestation Based Approaches (MBA) using representation filters are time and memory strenuous to convolve facial descriptions with a bank of conduits to extricate multi-orientation coefficients. Besides, extricating the Gabor highlights is serious calculation wise, therefore the highlights are unreasonable for instantaneous relevance such as versatile cellular phone programs [18]. To overcome this issue, a rearranged form of Gabor wavelets has been commenced in [19]. Regrettably, the clarified features of Gabor are lighter susceptible than the actual Gabor attributes. Hence in this [20] work, a Laplacian face approach is implemented for imaging conditions such as illumination, poses, expressions and also occlusions following Manifestation Based Approach, where local information is preserved by the LPP that finds an embedding and obtaining a facial manifold structure which is tested on Yale, JAFFE database where investigational consequences revealed that LPP with KNN methodology do better than as Principal Component Analysis with Artificial Neural Networks achieving lower error rate. Deep learning combined with CNN, DBN and DBM [21] is a recent proficient method in Manifestation Based Approach. In the comparative study of all the 2 dimensional techniques, the CNN is the best technique. The visual procedures in abode to the pattern recognition lead the CNN design [22] along with the neocognitron [23]. Duc Minh Vo suggested a method of combination of CNN and SVM techniques for FER problem [21] which demonstrated that substituting the classifier of CNN by SVM presents improved outcomes.

Again addressing the issues of Deep Learning, it needs to analyze a very giant set of parameters and does no longer entirely acquire the category tag and nearby configuration into account throughout the preparation phase. The research of the paper [24] has recommended a narrative tactic of Supervised Feature Learning Network (SFL Net).

Classifier: The researches and studies in the recent years suggested the techniques of inculcation of couples of classifiers to produce more accurate results for face identification. The combination not only offered accurate decisions but enhanced the exactitude and steadiness rather than the results came out of the single classifier techniques [25]. For automatic emotion recognition and to estimate the competence of diverse classifiers for Electro Encephalo Graphy supported signals, architecture was introduced by Xiao-Wei Wang [26] in which paper two feature extraction method was employed.

The classification of this extraction was performed by KNN-using euclidian distance method, MLP-using 3 layer neural network and SVM-using RBF kernel. The highest accuracy of 66.51% is obtained by SVM classifier. Pattern recognition and false regression problem can be dealt successfully with strong features of SVM for the maximization of the aloofness flanked by classes and ensuring the correctness of classification at the same moment and providing solutions to in adequate sample of face expression and huge difference of total among various expressions [8]. Marcus de Assis Angeloni proposed a part-based face detection technique in the paper [27] which used AR Face, MUCT and XM2VTS as the public datasets, 2D-DCT, Gabor filter, Gray Level Co-occurrence Matrices, HOG, MLBP as the feature descriptors, KNN, SVM, Random Forest as the classifiers and two fusion strategies where best performing method was Gabor feature and SVM classifier. Since the correlation between various features and classifiers therefore the merger of these can endow with the momentous expansions in the recognition rate [28].

Evaluation Protocols for the Datasets Benchmarking:

There are certain challenges in the field of face identification and detection, the data collection and its evaluation in a systematic and organized way is one of them [29]. In the paper [5], there are so many published benchmarks for the developments of datasets in face detection techniques are described. These benchmarks are now used in various evaluation protocols.

Name of database	Colour/grey	Imaging conditions
FERET	Colour (2D)	Controlled
ORL	Grey (2D)	Controlled
SC face	Colour (2D)	Uncontrolled
Yale B	Grey (2D)	Uncontrolled
CASIA	Colour (2D)	anti-spoofing
UMB-DB	3D	3D Models
UMB	3D	Occluded
3DMAD	3D	anti-spoofing
Mc Gill Faces	3D	Video

Table No. 1 List of some most widely used 2D, 3D and video benchmark datasets.

II. RELATED WORK

To attain successful recognition performance, most current face expression recognition strategies require some power over the image conditions for instance noise, posture effect and elucidation effect. For the enhancement of accuracy of face Recognition Techniques under the different lighting conditions, the paper [30] deals with a new-fangled method which is based upon the Weber-Face and Singular Value Decomposition (SVD) methodologies. The identification is done using an adjacent fellow classifier with Chi-square on the extended Yale B database which indicates that the projected technique can be achieved be the viable outcomes evaluated with LBP, WF– LBP approaches.

Moreover a synchronized face identification system presented in paper [31] which is an amalgamation of two techniques one is face detection using LBP and other is face recognition using SVM.

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Figure No. 3 (a) Multi-Face recognition: Two people facing the camera can be acknowledged
(b) Left: Harr-like outcomes Right: LBP outcome with deflection slant.

Furthermore, a three Dimensional cognitive model is premeditated by Maringanti Hima Bindu [15] to manage the potential of uncertainty classifications, negations along with the cognitive nature of the sentiments. This model was having an ability of classification of twenty two sentiments and had the capability to rise upon the range of emotions by defining the sentiments in terms of the positive and negative reinforcements.

This model use Histogram approach and Gabor filters for face detection, PCA for feature extraction and Gradient-based Back-propagation neural network which achieved success rate of 87.5 % on Cohn-kanade database. The factors subjected to different cultures (geographical regions) and age groups may execrate different expressions. Focusing on the existing issue of Attribute Extraction Algorithm and system identification performance, an innovative approach is presented by Yang Li [32] with the merger of feedback learning theory along with the theory of Neural Network and three dimensional LBP feature extraction process on FEGCv2.0 face database, ORL. In addition considering occlusions of eye and mouth of the input facial expressions, a region-based, 3-Dimensional face recognition approach is insinuated in paper [33].

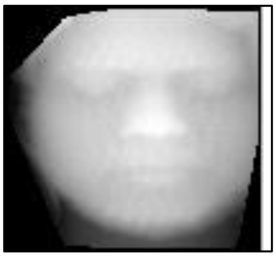
Factors improved/ Issues to deal with	Year & Paper Ref.	Input Image Size	No. of Emotions can be Classified	Used Algorithm For			Used Data base	Accuracy (%)
				Face localization	Feature extraction	Classification		
Uncertainty, contradiction, cognitive nature of emotions	2007 Maringanti Hima Bindu [15]	640x480	22(Flexible to increase more)	Discrete Hopfield Networks	Gabor Wavelet (GW) transform	PCA+Back-propagation neural network	Cohn-Kanade Action Unit Coded Facial Expression Database.	85.7
Low resolution image recognition using large & cross different dataset	2008 Caifeng Shan [34]	720x576 (MMI)	7		Boosted-LBP	Support Vector Machine (LINEAR)	MMI	86.7
							JAFFE	79.8
							Train:Cohn–KanadeTest: MMI	50.8
							Train:Cohn–KanadeTest: JAFFE	40.4
						SVM (POLY NOMIAL)	MMI	86.7
							JAFFE	79.8
		256x256 (JAFFE)					Train:Cohn–KanadeTest: MMI	50.8
							Train:Cohn–KanadeTest:JAFFE	40.4
						SVM (RBF)	MMI	86.9
							JAFFE	81.0
							Train:Cohn–KanadeTest: MMI	51.1
							Train:Cohn–KanadeTest: JAFFE	41.3
Global optimal discriminant feature	2009 Jingjing [7]	120x160 (Yale)	11	Adaboost	Genetic Algorithm	ANN + EDA	Yale	98.4
		120x180 (Feret)					Feret	82.5
EEG-based emotion recognition	2011 Xiao-Wei Wang [26]	720x480	4		Electroencephalogram (EEG) signals	KNN	Standard video image	59.84
						Multilayer perceptron		63.07
						SVM		66.51
Hybrid approach for eliminating issues related to global feature extracted by PCA	2012 Yuan Luo[8]	24x24		eight eyes and energy normalization	PCA	SVM+RBF	Intelligent wheelchair	91.25
					PCA+LBP			93.75
Reducing high computational complexity & lack of numerical precision	2012 Tran Binh Long [35]	80x80	7	Zernike moments-Artificial neural network	Pseudo Zernike moment invariant (PZMI)	Radial basis function (RBF) network	JAFFE	98.33
Pose, illumination, issues related to PCA	2014 M.E.Ashalatha [16]	60x60 (Yale)			LPP	KNN	Yale	97.14
		112x92 (ORL)					ORL	95.83
Fusion of classifier	2016 Duc Minh Vo[21]	224x224 x3	6		Deep CNN	Convolutional Neural Network (CNN)+SVM	Cohn-Kanade	96.04
Occlusion	2016 Koushik Dutta [33]	100x100	16	Weighted median filter	LBP + HOG	Nearest Centroid Classifier	Frav3D	88.86 (decision level)
								78.46 (Score level)
							Proposed	77.5 (Decision level)
								65.55 (Score level)
Illumination	2016 Chi-Kien Tran [30]	192x168		Weber face + SVD	LBP/LTP	NN with Chi-square	Extended Yale	98.87
Angle of head, multiface recognition, stranger identification	2016 Jiakailin Wang [31]	200x200		PCA	LBP +Adaboost	SVM	Real-time image	Satisfactory
Occlusion, illumination, issues related to DNN	2016 Dan Meng [24]	192x168 (Yale)			LLE	SFL Net	Extended Yale b	99
		83x60 (AR)					AR dataset	98

Table No. 2 A summary on some Facial Expressions Recognition Systems

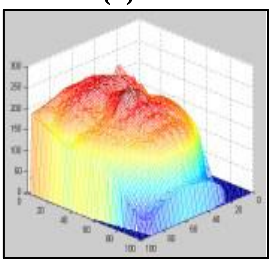
Histogram of Oriented Gradient (HOG) is proposed for computing feature vectors and finally for classification purpose. This Twofold Cross Corroboration Technique along with a classifier is employed on Frav Three Dimensional database with the limitation that pose variations are not considered.

(a)

(b)



(c)



(d)

Figure No. 4 (a) Two Dimensional representation (b) Three Dimensional position clouds (c) 2.5 Dimensional representation (d) Three Dimensional Mesh

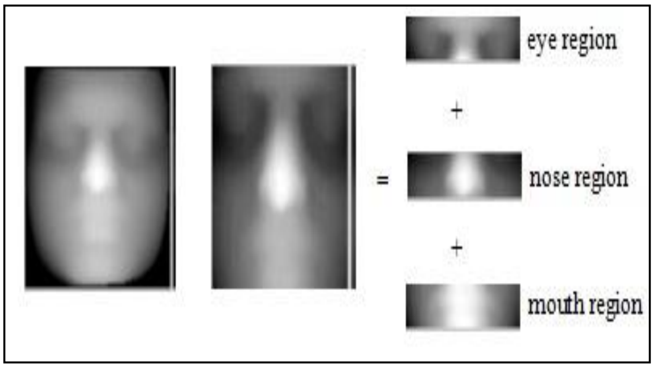


Figure No. 5 (a) Input Three Dimensional range Representation, (b) Rectangular Shorten Representation, (c) Area Dissection of resultant Shorten Representation

III. CHALLENGES

Although remarkable advancement has been achieved, state-of-the-art FER systems produce acceptable results merely beneath proscribed environments and decompose remarkably while deal with existent environments. Some of the examples in these confront [5] that may be due to the elucidation deviations, posture deviations, ageing effect, Cultural Changes and occlusion.

- The major challenge faced in face identification and detection techniques is the lack of the unprompted facial articulation databases.
- As per the conclusions presented by Sebe et al. in the paper [36], the face expressions will be different from natural conditions if the subject is provided with the prior information related to the capturing of the picture or video.
- The data captured under the different medical and lightening conditions will be different from the data tested on real test beds which will ultimately lead to a question on the authenticity [37].

IV. CONCLUSION

The current research focus upon the review of present or existing accomplishments of different researched carried out in the field of face recognition systems. This paper also presents a significant study of confronts, vital aspects and performance matrices of these systems. By including all the researches, we approach to a conclusion which though optimized preprocessing methods, better feature extraction approach, fusion of multiple classifier, 3D cognitive model can highly improve the achievement of face recognition system under controlled scenario, but still there are so many factors (such as creating database with spontaneous expressions of different age group and cultural individuals, finding out labeled data, optimal handling of illumination, occlusion, pose variations and so on.) to be focused on to achieve the efficacy of existing techniques on a extensive scale, unimpeded and highly challenging existent environment.

V. FUTURE SCOPE

The continuous contribution and progress of the research community working on face recognition have made few real world applications feasible. But still there are some confronts to highlight and chances to investigate for modeling the advanced face recognition techniques put into practice on the digital systems. More over these techniques should work in extremely demanding ecosystems. The scope of research in this field may include the followings:

- Other major concerns should be developing better illumination preprocessing methods, color information utilizing methods and implementation existing techniques & algorithms on Graphical Processors or graphical processing units.
- Again to resolve the issue of matching faces with changing postures, lighting and resolutions [38], there is a requirement of the development of the techniques which can complement the LR probe representations with the database of high-resolution representations.
- According to Wolf et al. [39], there is an ample space for the induction of new techniques and methods in the field of face recognition and detection.
- Further, since historically three dimensional face detection has been reprimanded for absence of cameras which are equipped with the three dimensional sensors.

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