An Improved Average Gabor Wavelet Filter Feature Extraction Technique for Facial Expression Recognition

Deepak Verma
Department of computer science
Jaipur National University, Jaipur, Rajasthan, India

Dr. Vijaypal Dhaka
HOD Department of Computer Science
Jaiput National University, Jaipur, Rajasthan, India

Shubhlakshmi Agrwal
Asstt. Prof. Department of Computer Science
ICFAI University, Jaipur, Rajasthan, India

Abstract- Facial Expression Recognition has been a very important topic for research in computer pattern recognition and currently there is no method of facial Expression recognition system that have 100% recognition rate. So research issues are to improve recognition rate by improving the pre-processing of datasets, improving the feature extraction method and using the best classifier for face recognition.The purpose of this research work is to increase the recognition rate for face expression recognition system by improving feature extraction method. Feature extraction is the key step on which recognition rate depends for facial gesture recognition. For increasing the recognition rate features using different ways or projection should be extract but there is probability of increasing of redundancy which can be responsible of reducing the recognition rate. High dimension and high redundancy is a problem issue for Gabor while it has maximum variance of features. Dimension and redundancy should be reduced using some technique. The dimension reduction technique for gabor is called filtering so this whole technique is called gabor filter. These filtering technique are sampling, average filtering etc. In the proposed gabor feature extraction technique the gabor features are filtered using wavelet transformation and obtained optimum features from facial dataset which give higher recognition rate compared to average gabor feature extraction technique and gabor sampling filtering feature extraction technique for facial expression recognition.

Keywords- Facial Expression Recognition, Gesture, Wavelet, Gabor Filter.

I. INTRODUCTION

Face of a human being has an important role in conveying the identity and the emotion or expression of the person. The Brain of Human being can store the pattern of millions of faces which have seen in their life period and can recognize the face which are similar to the face which have been seen earlier at single instance even after a long time of separation of period. In this context pattern recognition has attracted the attention of most of the scientist and philosopher. Computer-Aided facial expression Recognition System, which can identify the emotions or expression of a person by comparing the person's face to the face stored in database set, has wide range of application. Facial expressions are the facial changes in response to a person's internal emotional states, intensions, or social communications. Facial expression recognition has challenged many researchers not only from the field of pathology but also computer science. It can match verbal communication, or can convey complete thoughts by itself. Thus, to make use of the information afford by facial expressions, automated reliable, valid, and efficient methods of measurement are important [1]. Facial expressions have been studied by cognitive psychologists, social psychologist, neurophysiologists, cognitive scientist and computer scientists. There are seven basic expressions: neutral, anger, fear, disgust, happiness, sadness, and surprise which have to recognize in facial expression analysis. Due to its important practical application it has become attractive field of research in the last few decades with significant progress. Despite of advancement in the algorithm of Face recognition, it is still very challenging field

due to the various variations such as pose, illumination, occlusion and expression. Nonetheless, pose variation was identified as one of the prominent unsolved problems in the research of gesture recognition [2]. This focus follows from the work of Darwin [3] and more Ekman [4], who proposed seven basic expressions: neutral, anger, fear, disgust, happiness, sadness, and surprise. The Facial expressions are the facial changes of a person's internal emotional states, intension, or social communications. The various approaches of facial expression recognition is categorized into two categories, namely holistic based facial expression recognition and feature based facial expression recognition. Discrete transform is used for reduction of data redundancy as the primary step of holistic approaches [5]. Discrete cosine transform has strong data decorrelation and there are fast algorithms for DCT [6]. These properties make DCT useful in facial expression recognition in the area of pattern recognition [7]. Ramasubramanian and Venkatesh used a combination of the DCT, PCA and the characteristics of the Human Visual System for encoding and recognition of faces [8]. In [9] To decrease the effect of illumination variation the first three low frequency coefficients or the DC have been truncated. In facial Expression recognition Different Channels of Gabor Filter have different Distribution and reasonable combination of these features can improve the performance of facial Expression Recognition [10]. Gabor Filter is based on on spatial locality, scale and orientation on facial images. These images are most suitable for Facial Expression Recognition and Face Recognition because these are robust to variations, expression and scale [11]. Feature Extraction is mostly concentrate on facial expression information regions, so the mouth, eye and eyebrow regions are segmented from the images then low dimensional features are extracted using Wavelet Transform [12]. The Wavelet transform decompose the signal into high frequency sub-band (detailed components) and sub-band with low frequency (approximate components). Approximate components are consistent with characteristics of a signal and Detail components are related with noise and disturbance in a signal.

II. FEATURE EXTRACTION

Gabor Filter

Gabor filters can be applied to images to extract features aligned at particular angles. Gabor filters acquire optimal localization properties in both spatial and frequency domains. The most considerable parameters of a Gabor filter are angle and frequency. Certain features that share similar angle or frequency can be chosen and used to individualize between different facial expressions depicted in images.

A Gabor filter is a complex exponential transmogrified by a Gaussian function in the spatial domain.

A Gabor filter can be represented by the following equation 1[13]

$$\Psi(x, y, \lambda, \theta) = \frac{1}{2\Pi S_x S_y} e^{-1/2\left(\frac{x'^2}{S_x - S_x} + \frac{y'^2}{S_y - S_y}\right)} e^{j\omega \Pi x'/\lambda} \quad \ldots 1$$

where (x,y) is the pixel position in the spatial domain, λ is the wavelength (a reciprocal of frequency) in pixels, θ is the angle of a Gabor filter, and Sx, Sy are the standard deviation along the x and y directions consequently. The parameters x' and y' are given as equation

$x' = x\cos\theta + y\sin\theta \qquad y' = -x\cos\theta + y\sin\theta \quad \ldots 2$

The amplitude and phases of Gabor filter bank both contribute valuable cues about specific pattern present in images. The amplitude consists of directional frequency spectrum information and a phase contains information about the location of edges and image details.

The feature extraction method converts the pixel data into a higher-level representation of structure, movement, intensity, characteristic of surface, and spatial configuration of the face or its components. The Gabor features are computed by convolution of input image with Gabor filter bank. I(x, y) is a grey-scale face image of size M*N pixels. The feature extraction method can then be defined as a filtering operation of the given face image I(x, y) with the Gabor filter u,v(x, y) of size u and angle v are given as equation 3.

$G_{u,v}(x,y) = I(x,y) * \Psi(x,y) \quad \ldots 3$

In Gabor feature extraction method if Holistic approach is used than features are extracted from the entire image. Gabor filters are applied on images to extract features fix at particular angle (orientation) than the Gabor feature representation $|o(x,y)|_{m,n}$ of an image I(x,y), for x=1,2,.....N, y=1,2,....M, m=1,2...NL , n=1,2,....No, is computed as the convolution of the input image I(x,y) with Gabor filter bank function Ψ (x,y, λm,θn).The convolution operation is performed separately for real and imaginary part are given as equation 4.

$Re(O(x,y))_{m,n} = I(x, y) * Re(\psi(x,y,\lambda m,\theta n))$

$Im(O(x,y))m,n = I(x, y) * Im(\psi(x,y,\lambda m,\theta n)$ …4

This is followed by the amplitude calculation is given as equation 5

$|O(x,y)|m,n = ((Re(O(x,y))m,n)2 + (Im(O(x,y))m,n)2)1/2$ …5

Research Issues with Gabor Feature Extraction Technique

Beneficial issues of Gabor Technique are as following:

1. Gabor filters have the excellent localization property in spatial and frequency domain.
2. Gabor Filters are more robust than DCT for light variation.
3. Amplitude and phases provide valuable and maximum cues about specific pattern present in image.

Problem Definition of Gabor feature technique is as follows:

1) The Disadvantage of Gabor filter is it takes too high time for performing features due to its dimension of feature vector is very long.

2) Challenge of Gabor technique is it has high redundancy of features. Redundancy is responsible of reduce of recognition rate.

Research Issues: - High dimension and high redundancy is a problem issue for Gabor while it has maximum variance of features. Dimension and redundancy should be reduced using some technique. The dimension reduction technique for gabor is called filtering so this whole technique is called gabor filter. There is some filter technique which is proposed by researches. These filtering technique are sampling, average filtering etc.

Sampling Filtering

In Gabor, features are distributed uniformly so in Sampling Filtering a sample is created using selection of feature uniformly from large dimension Gabor. For example one gabor feature is selected from one gabor feature vector by difference of 25.

For example In sampling Filter, the time for calculating of Gabor feature extraction is very large and the dimension of the Gabor feature vector is very long also. For example an image of size of 256*256 pixels is transformed through a Gabor Bank of size (frequency =5, angle=7) 35 total in which 5 gabor feature matrix of size 25x25, 5 of 51x51, 5 of 76x76, 5 of size 102x102 and 5 of size 128x128 or a feature vector of length 178950 samples. for reducing the size of this feature vectors, down sampling using sampling filter can be performed without losing important information. When using the down sampling factor by 125, the length of each feature vector can be reduced to 1431 samples in feature vectors [14].

Average Gabor Filter

For above example, If average Gabor Filter technique is used then averaging of 5 gabor feature matrix of size 25x25 pixels is performed and converted to a single average feature matrix of size 25x25 pixels. Using Same averaging, 5 gabor matrix of size 51x51, 5 gabor matrix of size 76x76, 5 gabor matrix of size 102x102, 5 gabor matrix of size 128x128 are converted into a single matrix of size 51x51, 76x76, 102x102, 128x128 or average feature vector of size 35790.These matrix is called average gabor matrix and feature vector is called average gabor feature vector. Which is further reduced using down sampling process with a factor of 25 would further reduce it to a single feature vector of dimension 1431 and down sampling of 125 would reduce it to single feature vector of dimension 286 only. This vector is called average gabor filter vector [15].

Proposed Average Gabor Wavelet Filtering

A Wavelet transform of M*N pixel image produce M*N wavelet coefficients in transform matrix. Wavelet transformation is applied for for feature extraction, compression and reducing the. It is useful in face detection or expression recognition also. Wavelet transform represents the signals with small waves of limited durations which are called wavelets. It is applied for analysis of the signal both in frequency and time domains.

If $\Psi(t) \in L2(R)$, the basic wavelet, $\Psi(t)$ is defined as

$$C = \int_{-\infty}^{\infty} \frac{|\Psi(w)|^2}{w} dw \quad 6$$

Where $\Psi(w)$ is basic wavelet's Fourier Transform and w is circular frequency.

The wavelet transform decompose the signal into sub-band with high frequency called detailed components and sub-band with low frequency coefficient called approximate components. Approximate component are consistent with characteristics of a signal So useful dominant information about gesture and Detail components are related with noise and disturbance in a signal[16]. .The two-dimensional wavelet transform is performed by applying the one-dimensional wavelet transform to the rows and columns of the input image block, consecutively [17].
So we have to extract low frequency coefficient or approximate components from transformed wavelet coefficient matrix. In proposed average gabor wavelet filtering the wavelet transform is applied on each average gabor matrix which convert it into four equal sub band LL, LH, HL and HH in which LL sub band have most prominent information or characteristics features and HH sub band represent most redundancy. Using wavelet transform at one level a filtering of a factor of 4 is carried out on average gabor feature matrix.
For above example, DWT at level 2 is applied on average feature vector of size 25x25, 51x51, 76x76, 102x102 and 128x128 and information of LL sub band is selected for features which can be reduced using DWT on LL block of 1 level DWT of average gabor matrix. It is DWT at Lavel 2 which is reducing of a factor of 16. or a single feature vector size 2286 and which can be reduced further at DWT level 3 which reduce feature into a single feature vector of size 559.

III FEATURE EXTRACTION ALGORITHMS

Gabor Sampling Filter Feature Extraction Technique

Input : Gray scale Image Img
Step 1: Loop scale =[0.1,0.2,0.3,0.4,0.5]
Imgresize= image Img is resized with scale.
Step2: Loop theta=[0,30,60,90,120,150,180]
Apply Gabor equations with resized image Imgresize and angle theta.
Step3: End Loop
Stp4: End Loop
Step 5: for reducing the dimensions use sampling filtering by 25.
Step 6: for reducing the more dimensions use sampling filtering by 25 again.
Step6: Features is given to classifier.

Average Gabor Filter Feature Extraction Technique
Input : Gray scale Image Img
Step 1: Loop scale =[0.1,0.2,0.3,0.4,0.5]
Imgresize= image Img is resized with scale.
Step2: Loop theta=[0,30,60,90,120,150,180]
Apply Gabor equations with resized image Imgresize and angle theta.
Step3: End Inner Loop
Step 4: for reducing the dimensions:
Arithmetic Average is calculated for corresponding features of all 7 Gabor matrixes. It is a reduced matix by factor of 7 which is converted in feature vector.
Step 5: for reducing the dimensions use sampling filtering by 25 and merged into a feature vector F.
Stp6: End Outer Loop
Step7: Features is given to classifier.

Algorithm of Proposed hybrid feature extraction techniques
Input : Gray scale Image Img
Step 1: Loop scale =[0.1,0.2,0.3,0.4,0.5]
Imgresize= image Img is resized with scale.
Step2: Loop theta=[0,30,60,90,120,150,180]
Apply Gabor equations with resized image Imgresize and angle theta.
Step3: End Inner Loop
Step 4: for reducing the dimensions:
Arithmetic Average is calculated for corresponding features of all 7 Gabor matrixes. It is a reduced matix by factor of 7 ans is called average gabor feature matrix.
Step5: Apply Discrete Wavelet Transform on average gabor feature matrix at level 4 and LL4, LH4 and HL4 are merged into feature vector F.

Stp6: End Outer Loop
Step7: Features is given to classifier.

IV EXPERIMENTS & RESULTS

The simulation of proposed work is implemented in MATLAB and JAFFE dataset is used for evaluation of proposed algorithm for facial expression recognition. JAFFE data Set is used in my experiment is a set of 213 images of female facial expressions of 10 Japanese female models. In my experiment 150 (70 %) are training image and 63 (30%) are testing image among 213 images of size of 256 x 256 pixels in tiff image format. The number of images corresponding to each of the 7 categories of expression is approximately same. Adaboost Classifier is used for classification.

Figure. 1. Sample image of JAFFE dataset

Table-1 Comparative Analysis of Gabor Sampling Filtering, Average Gabor Filter and proposed Technique for Facial Expression Recognition

Methods	**Gabor Filter**	**Avg. Gabor Filter**	**Proposed Avg. Gabor wavelet Filter Technique**
Avg. Recognition rate (%)	**58.33**	**69.3**	**73.59**

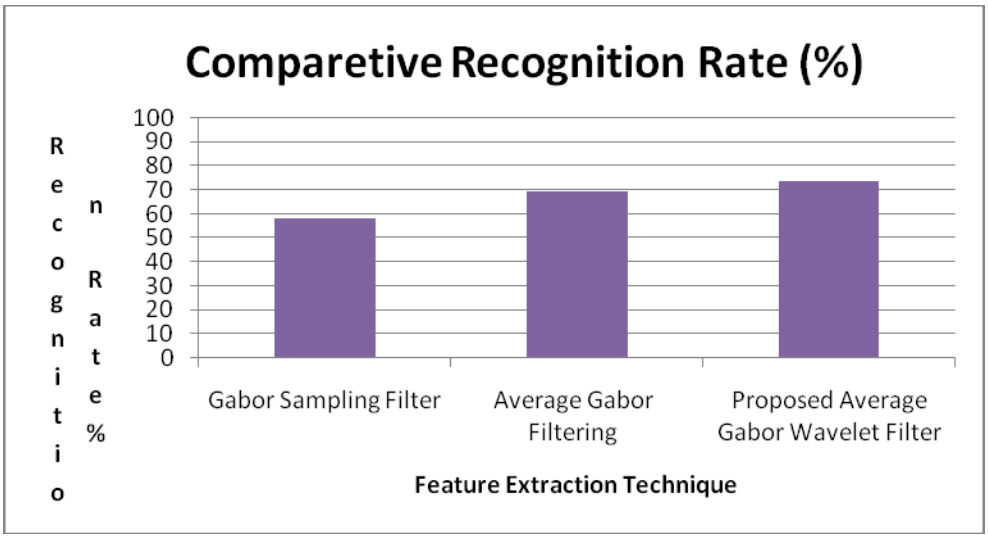

Figure 2 Graph of Results of recognition rate (in %) for Gabor Sampling Filter, avg. Gabor Filter and Proposed averaged Gabor wavelet Filter Feature Extraction Technique for Facial Expression recognition.

V. CONCLUSION

Feature extraction is the key step on which recognition rate depends for facial gesture recognition. For increasing the recognition rate features using different ways or projection should be extract but there is probability of increasing of redundancy which can be responsible of reducing the recognition rate. High dimension and high redundancy is a problem issue for Gabor while it has maximum variance of features. This high Dimension and redundancy should be reduced using some filtering technique. The dimension and redundancy reduction technique for gabor is called filtering so this whole technique is called gabor filter. These filtering technique are sampling, average filtering etc. In the proposed gabor feature extraction technique the gabor features are filtered using wavelet transformation and obtained optimum features from facial dataset. Proposed algorithms are implemented in Matlab and JAFEE dataset are used for experiment with ratio 70/30 of training/testing with adaboost classifiers for seven different facial expressions. The experiments result show that proposed hybrid method have 73.59 % average correct classification rate which is higher average correct classification rate compared to 69.3% for Average Gabor Filter and 58.33 % for Gabor Sampling Filter for facial expression recognition for JAFEE dataset with 70/30 training/testing ratio. The classification results of proposed work is compared with results of facial expression recognition methods based on gabor feature extraction technique with sampling filtering and average gabor filtering. The results shows that proposed technique have higher recognition rate compared to existing techniques.

VI. FUTURE SCOPE

Proposed hybrid method can be implemented with feature reduction techniques (example: PCA etc.) to further reduce the redundancy and improve the recognition rate. Proposed hybrid method can be combined with more features extraction techniques like Gaussian, Filter, Standard Deviation, Eigen Face, Principal Component Analysis, Kurtosis etc.

REFERENCES

[1] J.J.J.Lien., "Automatic recognition of facial expressions using hidden markov models and estimation of expression intensity". The Robotics Institute Carnegie Mellon University Ph. D. dissertation, 1998.
[2] Zhiliang Wang. "Artificial psychology - a most accessible science research to human brain", International Journal of University of Science and Technology Beijing, Vol.22, No.5 pp. 478-481, 2000.
[3] C. Darwin., "The expression of emotions in man and animals", John Murray, reprinted by University of Chicago Press, Chicago, 1965.
[4] P. Ekman, W. V. Friesen., "Constants across cultures in the face and emotion", International Journal of Personality Social Psychology, vol.17, no.2, pp. 124-129, 1971.
[5] P.J. Phillips W. Zhao, R.Chellappa and A. Rosenfeld. Face recognition: A literature survey. volume 35, pages 399–458. ACM Computing Surveys, 2003.

[6] C L. Wilson R. Chellappa and S.Sirohey. Human and machine recognition of faces : A survey. In Proceeding of IEEE, volume 83, pages 705–740. IEEE, 1995.
[7] Z.M. Hafed and M.D Levine. Face recognition using discrete cosine transform. Journal of Computer Vision, 43(3):167–188, 2001.
[8] D. Ramasubramanian and Y.V.Venkatesh. Encoding and recognition of faces based on human visual model and dct. volume 34, pages 2447–2458, 2001.
[9] W. Chen M. J. Er and S. Wu. High speed face recognition based on discrete cosine transform and rbf neural networks. volume 16, pages 679–691, 2005.
[10] WeiFeng Liu and ZengFu Wang. Facial expression recognition based on fusion of multiple gabor features. In IEEE International conference on Pattern Recognition. IEEE, 2006.
[11] W.L. Woo R.M. Mutelo and S.S. Dlay. Two dimensional principal component analysis of gabor features for face representation and recognition. In CSNDSP Proceeding, pages 457–460. IEEE, 2008.
[12] Fenguin Chen Zhiliang Wang Zhengguang Xu Jianng Xiao and Guojiang Wang. Facial expression recognition using wavelet transform and neural network ensemble. In International Symposium on Intelligent Information Technology Application, volume 24, pages 871–875. IEEE, 2008.
[13] Guoqiang Wang and ZongyingOu," Face Recognition Based on Image Enhancement and Gabor Features", Proceedings of the 6th World Congress on Intelligent Control and Automation, June 21 - 23, 2006, Dalian, China.
[14] XiaoliLi Qiuqi Ruan Chengxiong Ruan, "Facial Expression Recognition with Local Gabor Filters", International conference, IEEE, 2010.
[15] Seyed Mehdi Lajevardi and Margaret Lech, "Averaged Gabor Filter Features for Facial Expression Recognition", International conference on Digital Image Computing, IEEE, 2008.
[16] Wen Hu, O. Farooq and S. Datta,"Wavelet based sub-space features for face recognition", International conference on Congress on Image and Signal Processing, IEEE, 2008.
[17] Joohyun Lim, Youngouk Kim, and Joonki Paik, "Comparative Analysis of Wavelet-Based Scale-Invariant Feature Extraction Using Different Wavelet Bases", International Journal of Signal Processing, Image Processing and Pattern Recognition, Vol. 2, No. 4, December, 2009.