A Hybrid Algorithm Of Gabor Filter and Gaussian Distribution Feature Extraction Techniques for Facial Expression Recognition

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Abstract

Facial expression recognition is necessary for designing any human-machine interfaces. Facial expression plays an important role in the recognition of human emotions and non verbal communication. Human face is a rich and powerful source of communicative information about human behavior. In this dissertation work I contribute to design a feature extraction technique. An efficient facial expression recognition method is proposed. The method uses a combine set of features obtained from Gabor Filter bank with 3 frequencies and 5 different angles and the Gaussian distribution methods. The performance of the proposed method is compared with the Gabor Filter and Gaussian distribution methods. The classification tasks perform using the Adaboost classifier. The training and testing images selected from the publicly available JAFFE (Japanese Female Facial Expression) dataset. For the experimental work 70% data are used for training purpose and remaining 30% data are used for testing purpose. The classification results show that the proposed combine feature extraction methods of Gabor filter and Gaussian distribution provide high recognition rate compared to the individual Gabor filter and Gaussian Distribution Feature Extraction method.

Keywords: Feature Extraction technique, Facial Expression Recognition, Gabor Filter, Gaussian distribution, Hybrid.

1. INTRODUCTION

Facial expressions are the facial variance in responded 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 [1].

Psychologist Mehrabian recorded that for the effect of a message only 7% of the verbal part contributes, 38%contribution is of the voice intonation and rest 55% effect is produced by facial expression.

Computer vision based method to facial expression analysis critical among a small set of emotions. This target follows from the work of Darwin and more recently Ekman, who suggested six basic expressions: anger, fear, disgust, happiness, sadness and surprise.

Face recognition can also used for security reason. It is an application of biometric. A biometric recognition system is a computerized system that verifies or identifies a person's identity using a person's physiological attribute and/or behavioral attribute [3].A face recognition system is a computer application for spontaneously identifying or verifying a person from a digital image or a video frame from a video source. One of the methods to do this is by comparing selected facial features from the image and a facial database. And this is where the facial feature extraction technique passes it way in.

Facial expression recognition introduces both measurement of facial motion and recognition of expression. The general approach to facial expression recognition consists of five steps [2] as following Image acquisition, Preprocessing, Feature Extraction, Classification and postprocessing.

The objective of this research is comparative study of different feature extraction techniques for facial expression recognition. Develop a hybrid algorithm using Gabor Filter and Gaussian distribution techniques for feature extraction using Adaboost classifier to reduce the generalization error and improve performance by getting the high recognition rate using hybrid approach.

The rest of the dissertation work is organized as follows section 2 explain the feature extraction techniques. Section 3 explains the proposed work. Section 4 consists of experimental result and section 5 consist the conclusion and future work.

2. FEATURE EXTRACTION TECHNIQUE

2.1. Gabor Filter Feature Extraction Technique

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

A Gabor filter can be represented by the following equation [4].

$$\Psi(x, y, \lambda, \theta) = \frac{1}{2\Pi SxSy} e^{-1/2\left(\frac{x'^2}{Sx \cdot Sx} + \frac{y'^2}{Sy \cdot Sy}\right)} e^{j2\Pi x'/\lambda}$$

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.

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

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.

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

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 .

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

$$Im(O(x,y))_{m,n} = I(x, y) * Im(\psi(x,y,\lambda_m,\theta_n))$$

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

$$|O(x,y)|_{m,n} = ((Re(O(x,y))_{m,n})^2 + (Im(O(x,y))_{m,n})^2)^{1/2}$$

2.2. Gaussian Distribution Feature Extraction Technique

Gaussian processes are excellent approximations to the investigation. A number of processes can be approximated by a Gaussian random process. The multivariate Gaussian distributions are experimentally simpler. One of the most important uses of the Gaussian process is to model and investigate the effects of thermal noise in communication systems.

A d-dimensional Gaussian distribution is given as equation.

$$p(x) = \frac{1}{2\pi^{d/2}|\Sigma|^{\frac{1}{2}}} e^{\frac{-(x-\mu)^T\Sigma^{-1}(x-\mu)}{2}}$$

Mean vector and covariance matrix is represented by μ and Σ respectively. The random vector x satisfies the Gaussian distribution with mean μ and Σ is notated by x N (μ, Σ). The curve (shape) of constant density for the d-dimensional Gaussian distribution is ellipsoids defined by the following equation.

$$(x-\mu)^T\Sigma^{-1}(x-\mu) = c^2$$

The ellipsoids are centered at μ and have axes $\sqrt{\lambda_i e_i}$, where ei is an eigenvector of Σ and λi is the corresponding Eigen value.

3. PROPOSED METHOD

Every feature extraction technique for facial expression recognition has its own advantages. So each technique can extract only limited features with redundancy and a limited recognition rate is possible with its own extracted feature. For achieving higher recognition rate different feature extraction techniques are combined into a single combined technique to maximize the features. Using hybrid combinations advantage of different techniques also merged in proposed technique. Following Proposed algorithm extract the features of Gabor Filter and Gaussian Derivative.

- The Gabor features are calculated by convolution of input image with Gabor filter bank and down-sampling by factor 2.In our experiment we use 3 frequencies and 5 angle. These features are kept in feature vector Fg.
- The 2 D Gaussian distribution is used to generate the mask. Different types of masks can be specified by parameters Dx, Dy. By default the size of the mask is 8*SIGMA, 8*SIGMA. Five dimensional feature vectors are computed at each pixel by convolution with the first derivative (Gx,Gy) of Gaussian in x and y direction and second derivative (Gxx, Gxy, Gyy) is used. This is Gaussian feature vector Fgu.

- Finally Feature vector Fg and Fgu are merged in feature Vector F.

4. EXPERIMENTS AND RESULTS

For calculation of proposed algorithm for facial expression recognition JAFFE dataset is used. JAFFE dataset include 213 images of seven facial expression pretend by 10 Japanese female and each person pretend 3 or 4 images for each expression (anger, fear, digust, happy, natural, sad, surprise). For the experiments around 70% data for training and remaining 30% data are used for testing purpose. 256*256 images of JAFFE dataset are used without any preprocessing. The Adaboost classifier is used for classification of facial expressions. Facial expression recognition using Gabor filter is executed as section 2.1 .Facial expression recognition using Gaussian distribution is executed as section 2.2. Facial expression recognition using proposed work is executed as section 3. Result of facial expression recognition achieve from above feature extraction techniques on JAFFE dataset are shown in Table 4. Confusion table of facial expression recognition using Gabor Filter, Gaussian distribution and proposed work are shown in Table 1,.2,.3 consequently. Figure 1 show the compression graph of recognition rate for different facial expression using Gabor filter, Gaussian distribution and proposed work.

Table 1.Confusion Table of Recognition Rate (%) for facial expression using Gabor Filter

Expressions	AN	DI	FE	HA	NA	SA	SU
AN	**60**	20	0	0	20	0	0
DI	11.1	**66.6**	0	22.2	0	0	0
FE	8.33	16.6	**50**	0	8.33	0	16.6
HA	0	18.2	18.2	**54.5**	0	9.09	0
NA	20	0	0	0	**80**	0	0
SA	0	9.09	0	0	9.09	**81.8**	0
SU	0	0	0	0	20	0	**80**

Table 2.Confusion Table of Recognition Rate (%) for facial expression using Gaussian Distribution

Expressions	AN	DI	FE	HA	NA	SA	SU
AN	**70**	10	0	0	20	0	0
DI	11.1	**55.5**	11.1	0	0	11.1	11.1
FE	8.33	0	**58.3**	25	0	0	8.33
HA	0	0	9.09	**63.7**	0	9.09	18.2
NA	20	0	10	0	**60**	0	10
SA	18.2	18.2	0	0	0	**54.5**	0
SU	0	0	0	10	0	0	**90**

Table 3.Confusion Table of Recognition Rate (%) for Facial Expression using Proposed Combined Feature Extraction Techniques

Expressions	AN	DI	FE	HA	NA	SA	SU
AN	**80**	10	0	0	10	0	0
DI	11.1	**77.7**	11.1	11.1	0	0	0
FE	8.33	8.3	**67.7**	8.33	8.3	0	8.3
HA	0	0	9.09	**72.73**	0	9.09	9.09
NA	10	0	0	0	**90**	0	0
SA	0	10	0	0	0	**90**	0
SU	0	0	0	0	10	0	**90**

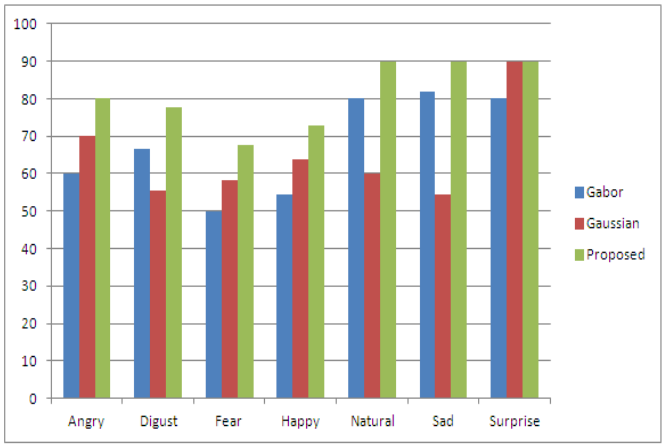

Fig.1. Comparison Graph of Recognition Rates for different Facial Expression using all three Feature Extraction Techniques

Table 4. Recognition Rate of Different Feature Extraction Methods

Methods	Gabor Filter	Gaussian Distribution	Hybrid Technique
Avg. Recognition rate (%)	66.9	63.7	79.8

5. CONCLUSION

Experimental results show that proposed techniques have 79.8% recognition rate. While Gabor filter method has 66.9% recognition rate and Gaussian distribution has 63.7% recognition rate. The percentages of the correct classification vary across different expressions from 50% to 82% for Gabor Filter and from 54% to 90% for Gaussian distribution and from 67% to 90% for proposed technique. In this paper we conclude that when we combine the best features of different technique then we get the best features vectors which improve some recognition rate of facial expression.

6. REFERENCES

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