Facial Expression Recognition using Gabor Wavelet

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ABSTRACT
Facial expression recognition (FER) has good applications in different aspects of day-to-day life. But not yet realized due to unavailability of effective expression recognition techniques. This paper discusses the application of Gabor filter based feature extraction by using feed-forward neural networks (classifier) for recognition of four different facial expressions from still pictures of the human face. The study presented here gives simple method in facial expression recognition. The study presented here gives 72.50% recognition of facial expression for the entire database of JAFEE. In this study the Japanese Female Facial Expression (JAFFE) database used which contains expressers that expressed expressions.

Keywords
PCA, GABOR, FER, JAFFE.

1. INTRODUCTION
Facial expressions provide an important behavioral measure for the study of emotions, cognitive processes and social interaction and thus automatic facial expression recognition systems can provide a less intrusive method to apprehend the emotion activity of a person of interest. With the availability of low cost computational devices, automatic facial recognition systems can be used in different applications such as identifying suspicious persons or theft in airports, railway stations and other places as precautions against terrorism attacks.

It is acknowledged that automatic recognition of facial expressions from face (color and gray-level) images is complex in view of significant variations in the physiognomy of faces with respect to head pose, environment illumination and person-identity [7]. Even the normal color (and gray-level) face images exhibit considerable variations, and contain redundant information (among pixels) in intensity for describing facial expressions. A direct use of a (color or gray-level) face image has not been successful in expression recognition in spite of normalization techniques to achieve illumination, scale and pose invariance. The implication is that appropriate features are needed for facial expression classification, as, in fact, evidenced by the observed human ability to recognize expressions without a reference to facial identity [8, 9].

During the past two decades, facial expression recognition has attracted a significant interest in the scientific community, as it plays a vital role in human centered interfaces. Many applications such as virtual reality, video-conferencing, user profiling and customer satisfaction studies for broadcast and web services, require efficient facial expression recognition in order to achieve the desired results [10,11]. Therefore, the impact of facial expression recognition on the above-mentioned application areas, is constantly growing. Several research efforts have been performed regarding facial expression recognition. The facial expressions under examination were defined by psychologists as a set of six basic facial expressions (anger, disgust, fear, happiness, sadness and surprise) plus the neutral state [12]. In order to make the recognition procedure more standardized, a set of muscle movements known as Facial Action Units (FAUs) that produce each facial expression, was created, thus forming the so-called Facial Action Coding System (FACS) [13]. These FAUs are combined in order to create the rules governing the formation of facial expressions, as proposed in [14]. A survey on the research made concerning facial expression recognition can be found in [15, 16]. Many approaches have been reported regarding facial expression recognition (direct or based on FAU recognition). These approaches can be distinguished in two main directions, those that use texture information (e.g. pixels intensity) and the rest that use geometrical or shape-based information (e.g. feature node displacements).

2. LITERATURE REVIEW
This paper introduced a multi-posed face detection and expression identification system which is more robust than the other proposed face detection system and facial expression system. This system is based on hybrid-boost multi-class learning algorithm as well as three decision rules which generates higher detection rate and lower false alarm rate. The experimental results show that the system has better performance than the others using Harr-like feature or Gabor feature [1].

This paper proposed a hybrid facial expression recognition framework in the form of a novel fusion of statistical techniques and the known model of a human visual system. An important component of this framework is the biologically inspired radial grid encoding strategy which is shown to effectively down sample the outputs of a set of local Gabor filters as applied to local patches of input images. Local classifiers are then employed to make the local decisions, which are integrated to form inter- mediate features for representing facial expressions globally. The recognition accuracies obtained on application to standard individual databases have been shown to be significantly better [2].

The methods about how to effectively extract expression features and recognize expression is studied in this paper. Firstly, they segment the face image from each image in the image sequence, and execute the operations of gray and scale normalization, circumrotation revision for the sub-face image. Then a hybrid feature extraction method based on AAM and Gabor wavelet transformation is presented in this paper. Experiments show that there method can recognize the six basic expressions effectively. Especially for the easily confused expressions such as angry, sad, fear, etc [3].

FER by computer is very useful in many applications such as human behavior interpretation and human-computer interface. Comparison of the recognition performance with different

types of features shows that Gabor wavelet coefficients are much more powerful than geometric positions [4].

This paper introduced an idea to develop a feature vector which consists of three types of facial variations and is robust against the expressional changes in the human faces in real environments. Since the training set consists of the facial expressions information of a person, it can recognize the person even under various expressions. A Bayesian Network (BN) classifier is efficient to train and classify. However the benchmarked database consists of only frontal view of faces. This technique is capable of working in real time environment. This system is a constituent of HRI system. It can keep the person identity information even under the presence of facial expressions which could originate under human machine interaction scenarios [5].

Facial feature extraction attempts to find the most appropriate representation of the face images for recognition. There are mainly two approaches: holistic template-matching systems and geometric feature-based systems. In holistic systems, a template can be a pixel image or a feature vector obtained after processing the face image as a whole. In the latter, principal component analysis and multilayer neural networks are extensively used to obtain a low-dimensional representation. In geometric feature-based systems, major face components and/or feature points are detected in the images. The distances between feature points and the relative sizes of the major face components are computed to form a feature vector. The feature points can also form a geometric graph representation of the faces. Feature-based techniques are usually computationally more expensive than template-based techniques, but are more robust to variation in scale, size, head orientation, and location of the face in an image [6].

3. METHODOLOGY

3.1 FER System

A practical facial expression recognition system is shown in Figure 1 below. The Recognition process begins by first acquiring the image using an image acquisition device like a camera. The image acquired then needs to be preprocessed such that environmental and other variations in different images are minimized. Usually, the image preprocessing step comprises of operations like image scaling, image brightness and contrast adjustment and other image enhancement operations. In this study, an existing image database of human facial expressions is used to train and test the performance of the classifier.

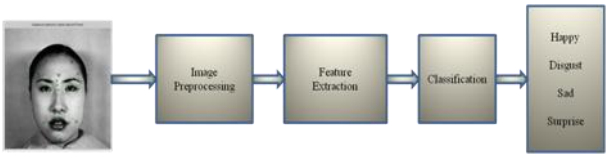

Fig 1: Facial expression recognition technique overview.

3.2 Image Preprocessing

In science, image processing is form of processing. The image is input for this system, such as a photograph or video frame; the output of image processing will be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques use the two-dimensional signal and applying standard signal-processing techniques to it.

Image processing usually refers to processing. Figure 2 shows example of image processing with scaling and contrast control.

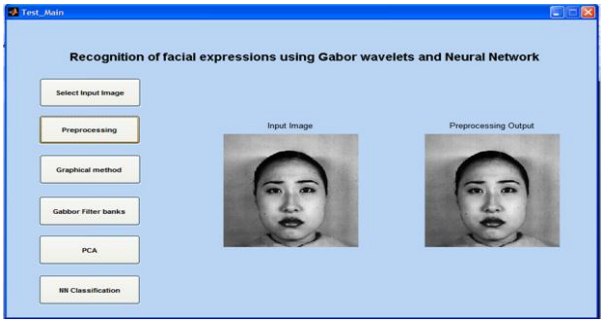

Fig2: Image Processing for Facial Expression Recognition using GUI Model.

3.3 Feature Extraction

In order to recognize facial expressions from frontal images, a set of key parameters that best describe the particular set of facial expression needs to be extracted from the image such that the parameters can be used to discriminate between expressions. This set of parameters is called the feature vector of the image and the amount of information extracted from the image to the feature vector is the single most important aspect of successful feature extraction technique.

Fig3: Selection of Fiducial points.

3.4 Two D Gabor Function

A 2-D Gabor function is a plane wave with wave-factor k, restricted by a Gaussian envelope function with relative width σ:

$$\Psi (k, x) = k^2/\sigma^2 (\exp (-k^2 x^2/2 \sigma^2)) [\exp (ik, x)-\exp(-\sigma^2/2)] \quad (1)$$

The value of σ is set to pi for the image of resolution 256 x 256. A discrete set of Gabor kernels is used that comprises of 5 spatial frequencies and 8 distinct orientations that makes a filter bank of altogether 40 different Gabor filters. The 40 different Gabor filter kernels obtained as described above. The outputs of Gabor filter for selected fiducial points are convolved with image for the selected co ordinates of fiducial points. The resulted vector is called as feature vector and length of feature vector will be number of Gabor filter multiplies number of fiducial points.

Table 1. Analysis of four expressions

Emotions	Result for 4 Emotions										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Disgust	sad	disgust	disgust	sad	sad	disgust	disgust	disgust	disgust	disgust	7
Happy	happy	happy	surprise	happy	happy	surprise	happy	happy	happy	surprise	7
Sad	sad	disgust	sad	sad	disgust	sad	sad	sad	disgust	sad	7
Surprise	surprise	happy	surprise	surprise	happy	surprise	surprise	surprise	surprise	surprise	8
										% Result	**72.5**

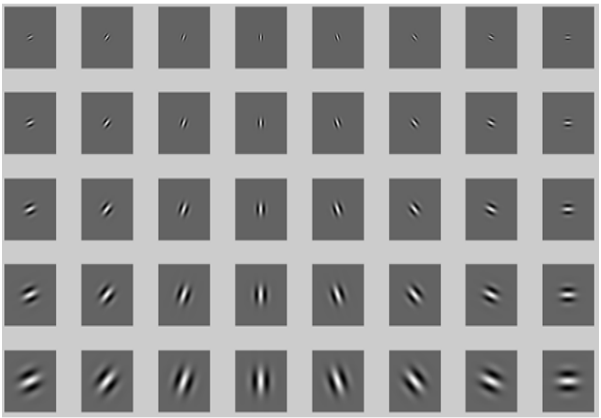

Fig4: 40 Different Gabor Filter.

3.5 Principal component analysis

PCA is a technique used to lower the dimensionality of a feature space that takes a set of data points and constructs a lower dimensional linear subspace that best describes the variation of these data points from their mean. PCA is a linear transformation commonly used to simplify a data set by reducing multidimensional data sets to lower dimensions. By using PCA, dimensionality reduction in a data set can be achieved while retaining those characteristics of the data set that contribute most to its variance, keeping lower order principal components and ignoring higher-order ones. PCA has the distinction of being the optimal linear transformation keeping the subspace that has largest variance. Unlike other linear transforms, PCA don't have a fixed set of basis vectors. Its basis vectors depend on the data set. In this study, length of feature vector can change from 1280 to a desired length. The length of feature vector is variable we can take the length of the feature vector such as 10, 20 up to 1280 to improve the recognition rate.

3.6 Classifier

The back-propagation algorithm has emerged as the workhorse for the design of a special class of layered feed-forward networks known as multilayer perceptrons (MLP). A MLP has an input layer of source nodes and an output layer of neurons; these two layers connect the network to the outside world. In addition to these two layers, the multilayer perceptron usually has one or more layers of hidden neurons, because these neurons are not directly accessible. The hidden neurons extract important features contained in the input data.

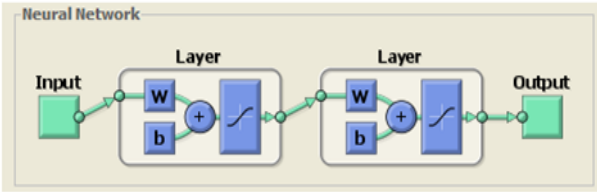

Fig5: Classifier.

By using the feed-forward neural networks (32 input, 2 hidden layers, 40 to 60 hidden neurons and four outputs) we can classify the input images such as happy, disgust, sad and surprise.

4. RESULT

Detailed implementation of above steps leads to obtain following results where one sample image has been selected randomly. Processing is done on the same image for obtaining best feature representation. Then feature points are selected as shown in figure 3. A discrete set of Gabor kernels is applied to image. Convolution of real Gabor with Image is taken over selected fiducial points to generate feature vector. Length of feature vector is reduced by using PCA. Reduced feature vector is applied to NN classifier to get the results shown in Figure 6.

From below example of image the output window of Facial Expression Recognition using GUI Model generates the message "Recognized facial expression is Disgust". Results obtained with this procedure for randomly selected images are around 72.50% which has been demonstrated with following Table 1and Figure no. 7.

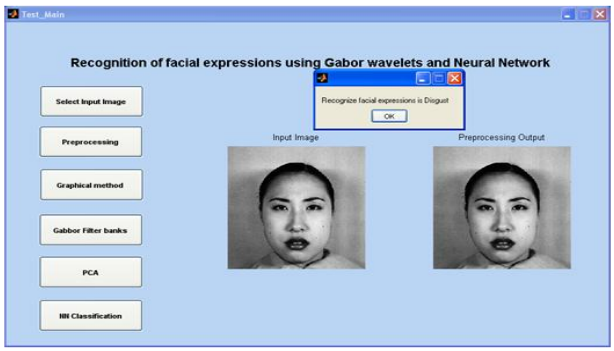

Fig6: Facial Expression Recognition using GUI Model (Example).

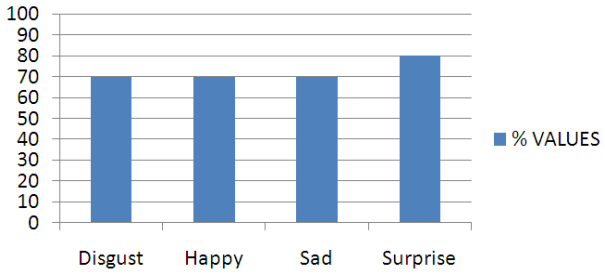

Fig7: Percentage Result of 4 Class FER System.

5. CONCLUSION

This system avoids difficulties in facial expression recognition (FER) due to the variation of facial expression across the human population. It can analyze facial expression feature extraction methods. Classifier will compare the facial expression & classify. So in this way we can conclude that we can recognize facial expressions by using Gabor wavelet with 72.5% results.

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