Australian Journal of Basic and Applied Sciences, 5(7): 1127-1132, 2011
ISSN 1991-8178

A Training Model for Fuzzy Classification System

Amir Jamshidnezhad, Md Jan Nordin

Centre for Artificial Intelligence Technology, University Kebangsaan Malaysia(UKM), Bangi, Selangor Darul Ehsan, Malaysia

Abstract: In recent years, Fuzzy Logic is considerably used as an intelligent technique to solve the ambiguous problems which are in the human life. Classification of emotions is one of the challenging problems deals with natural conditions of human face, linguistic and paralanguage. As the understanding of emotions, is highly depended on the facial expressions, in this paper a feature based hybrid system is proposed to classify the facial expressions to the basic emotions. The core of expression recognition system is a Mamdani-type fuzzy rule based system to model mathematically the natural conditions. Also, with the purpose of making better performance of fuzzy rule based system, Genetic learning Processes designed for parameter optimization to improve the accuracy and robustness of the system under adverse conditions. To evaluate the system performance, images from Cohn-Kanade database were used and the accuracy rate of 92 % was obtained.

Key words: Classifier, Facial expression recognition, Fuzzy system, Genetic algorithm, Pattern recognition

INTRODUCTION

The importance of classification is known in variety domains of human life such as: Medical, Geology, Biology, Economic, Business, Robotics, Human Computer Interactions (HCI) and Biometrics. Classification makes a comprehensible structure of objects to set them in the real situation. It separates area of data into different categories according to their characteristics and qualities. So that, each class includes most similar objects against the others. Classification of facial expression is one of the important phases of emotions recognition systems. If a computer could recognize the emotions of a user, the user would be able to work and communicate with the computer more easily and efficiently.

There is a variety of applications for facial expression recognition systems: In the animation design, if the animation character simulates the motions based on the human action, the results are more closely to reality. Moreover, in the virtual video communication where the bandwidth does not has the capacity to transfer the video data. The animation character can simulate the human emotions. In the digital cameras for capturing the emotion events and also in the E-commerce for customer relation management (CRM) system, emotion recognition is used to analyze of customer behaviors and motivations.

The well known facial expression model proposed in the research by Ekman and Friesen in 1978. They showed that there are certain universal emotions from facial expressions which are similar in different cultures. Based on Ekman and Frisen studies, there are at least six basic expressions; Happiness, fear, anger, disgust, surprise, and sadness. Facial Action Coding System (FACS), a well know collection of facial features for expression recognition, is also introduced by Ekman. Based on FACS, 46 important Action Units (AUs) which are directly related to the movement of eyes, eyebrows and mouth show the facial behaviors (Li Tian, 1999). Another important facial feature set is MPEG-4 system which is used for facial expression recognition. MPEG-4 standard specifies 84 feature points on the neutral face which are arranged in the areas like eyes, eyebrows, nose and mouth.

Facial Expression Recognition Systems:

Many Facial Expression Recognition systems have been studied in recent years. Difference in ages, genders and cultures are some reasons that challenge development of facial expression recognition. Classifier has important role to analyze the variation such as these in the face images for recognizing the six basic emotions from each other (Fasela, 2003). A wide range of algorithms has been proposed to the facial expression recognition problem (Xiang, 2008). In the following parts, we describe some of facial expression recognition approaches:

Corresponding Author: Amir Jamshidnezhad, Centre for Artificial Intelligence Technology, University Kebangsaan Malaysia(UKM), Bangi, Selangor Darul Ehsan, Malaysia

Hidden Markov Model:

Hidden Markov Models (HMMs) have been widely used to model the behaviors of facial expressions from sequence images. A system based on HMM with using MPEG-4 parameters for analysis was reported by M. Pardas *et al*. (2002). In this research the Cohen-Kanade database was used for training and recognizing the expressions. They modeled a four-state HMM for each emotion which was selected after testing different configurations. The system showed the overall recognition rate of 84%.

Support Vector Machine:

In J.M. Susskind *et al*. (2007) applied Support Vector Machine (SVM) for facial expression recognition automatically. In this study the performance of SVM compared with the human judgment for facial expression recognition. The results showed the corrected classification rates for human and SVM model were 89.2% and 79.2% respectively. Also A. Getta *et al*. (2009) used the SVM to find the optimum distinguish between two facial expression recognition (neutral and smile). The experiment results of the proposed real time system showed an accuracy of 98.5% for facial expression recognition. SVM is a successful technique for classification, however, as it is a binary classifier, it needs to long training time and also has more error rate, where there is multiple classes for classification.

Bayesian and Neural Networks:

Cohen *et al*., (2003) develop a system based on Bayesian network classifier to recognize seven facial expressions by using the maximum likelihood estimation. In L. Ma and K. Khorasani (2004) used Neural network (NN) systems in facial expression recognition. They proposed a constructive feed forward neural network for determining a proper network size required by the complexity of a given problem. In this approach, one-hidden-layer feed forward neural network obtained with block size of 12 and a maximum of 6 hidden units and the best recognition rate of 93.75%.

In RBF neural network is applied by Seyedarabi *et al*. as classifiers of facial expression. In this research they proposed a RBF neural network for classifying of the facial expressions from continuous video sequences. Seven features extracted from 21 feature points of eye, eyebrow, mouth, nose and cheek area, form a feature vector for each expression. The best rate was reported 91.2% for four facial expression recognition.

PCA and LDA:

In S. Dubussion *et al*, (2002) combined PCA and decision tree for six facial expression recognition and reported the accuracy rate of 87.6%. In X. Chen (2003) proposed a new method of LDA classification which is named CDA (Clustering based Discriminate Analysis) and reported 93% recognition of tree emotion. The classical linear method such as PCA and LDA are simple and efficient because they are linear. However, those are not suitable for representing dynamically changing facial expressions because the changing expressions are inherently non-linear.

Fuzzy Logic:

In T. Xiang *et al*, (2008) employed Fourier transform to extract features to represent an expression. For further expression processing the Fuzzy C Means (FCM) is used to generate a spatio-temporal model for each expression type. In this research the Cohen-kanade database is used for training and testing the model and the best test results was 88.8%. Smile and sadness have the best and worst recognition rates respectively.

In A. Khanum *et al*, (2009) proposed a hybrid system of fuzzy logic and CBR which has capability to improve the facial expression recognition. They reported the rate of 90.33% for emotion recognition.

In H. Ebin *et al*, (2001) used fuzzy logic for recognition of four emotions (joy, sadness, anger, and surprise) and reported the rate of 86.7% for test result.

In this paper, we proposed a training model of fuzzy rule based classification to fit the best parameters for recognition of different facial expressions. For the purpose of evaluating performance of the model, static facial images from Cohen-Kanade database are used. Experiment results showed that genetic algorithm considerably increase the accuracy rate of fuzzy rule based classification method as a training technique in the complex patterns recognition. System main framework has been described in the following parts.

Expression Recognition System:

The face normalization, the face segmentation as well as some specific facial feature extraction are important steps that the accuracy of classification methods are depends on them for facial expressions recognition system.

For the purpose of feature extraction four basic emotions as the facial expressions to be detected. Normalization is operated automatically. In order to reduce the complexity of the feature extraction module, a simplified feature extraction scheme is used for using only fifteen basic facial action points with the following steps:

- Selecting the feature points manually based on psychological surveys and literature studies. In this phase fifteen feature points is selected from G. Lipori's study which includes manual annotations of 59 facial fiducial points on the Cohn- Kanade database, (2000).

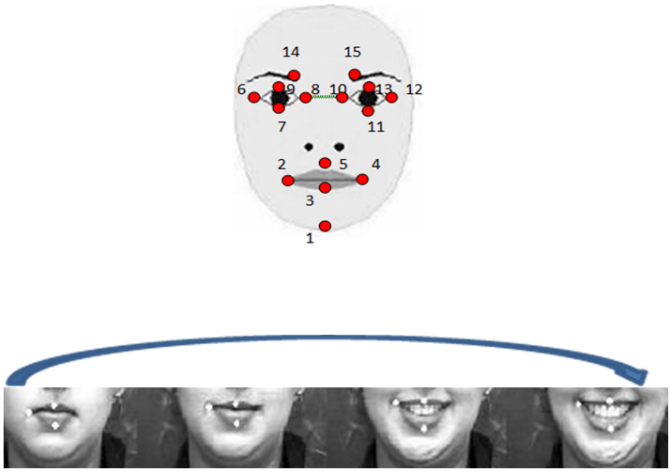

Fig. 1: Facial feature points.

- Removing the effect of object distances from the camera. The distance between the corners of two eyes is defined as the principal parameter of measurement. Therefore all feature points are normalized based on this distance.
- Removing the head rigid motions.
- Genetic-Fuzzy Classifier Model

With the purpose of making better performance of fuzzy rule based system, Genetic learning Processes designed for parameter optimization (Herrera, 2005). In this paper, fuzzy rule based system combined with the Genetic Algorithm is proposed to reduce the time needed for training and to improve the robustness of the system under adverse conditions (Jamshidnezhad, 2001). This integration is especially useful in classification problems where it is hard to find crisp distinction between two classes.

Fuzzy Rule Based System:

Rule base is made based on the empirical studies of changing the feature extracted from neutral to one emotion expression. Inference system, based on the rules classifies input feature vectors into one of the six basic emotions.

For feature extracted, six linguistic variables can be defined: a) Very Very Small, b)Very Small, c) Small d) Medium, e) Large, f) Very large. An example of rule is showed as follow:

If f1: medium And f2: small And f3: medium And f4: medium And f5: very large And f6: large And f7: medium then expression is Happiness.

In this paper, Bell shape membership function is used to map inputs to membership values. Bell shape membership function is one of the fuzzy membership functions that is often used to represent the natural problems:

$$ì(x)= 1/1+(|(x-c)/a|)^2b \quad (1)$$

Where the parameter *b* is usually positive which changes the shape. The parameters *c* and *a* locate the center and width of the curve, respectively.

In the proposed system, a Genetic Algorithm (GA) based method for the adjustment of membership functions of antecedent fuzzy sets in fuzzy rules for classification problems is developed. The modification of the restriction on the shapes of membership functions improved the performance of the classification system.

The process of GA is as follow:

a) Define the Choromosome Length:

There are seven extracted features (f1- f7) and each of them have six linguistic variables (VVS, VS, S, M, L and VL) and also each Bell shape membership function has three parameters, so we have 126 (7*6*3) Genes in each chromosome Ci = (G1,G2, ... , Gn).

b) Fitness Function:

Fitness functions is derived from the following objective function:

$$Min\ f(x) = 1 - \sum_{k=1}^{c} \left(\frac{mk}{nk} \right) \quad (2)$$

Where the ***mk*** is the numbers of correct classification for selected training data include six classes and, is the total of training data.

c. Parent Choromosome:

The Roulette wheel technique is used for selecting the pairs of chromosomes from the current population.

d. Crossover:

Two points crossover technique is used for creating a pair of offspring. The position of the points of crossover is selected randomly but separately for the genes which are related to the centre and width and beta parameters. It means the crossover operates just on the centres genes without changing in the width and beta parameters and again operates just on the width and finally operates on the beta parameters.

e. Mutation: Mutation apply with the probability of 0.1:

Reproduction:

Best chromosome which have the best fitness, is selected between the offsprings and the primary population. The new population is created based on the best chromosomes.

f. Termination Conditions:

The process of step of "*c*" to "*f*" will be repeated until the termination criterion will be satisfied. Terminating conditions are: 1) Fixed number of generations reached, 2) The highest ranking solution's fitness is reached.

Experiment Results:

The proposed model was evaluated on the images of Cohen- Kanade database which are separated in two groups: training and test group. In the training phase, when number of generation in GA reached to the 60 or the fitness function obtained the highest rank, generation is terminated, therefore, the improved membership functions used to the test group. In the testing phase the best accuracy rate of 92% was obtained for four facial expressions. All six basic facial expressions were recognized in two steps. In each step the system classified four emotions. Table 1, shows the overall experiment results:

Conclusion:

Pattern recognition in the domain of facial image is one of the challenging areas. In recent years, many researchers developed several classification methods to recognize various emotions based on the images of human face. Although there is a wide range of methods commonly used to facial expression recognition, however the variety of facial expression is caused the complexity in the recognition systems. Therefore, our objective in this research was development of facial expression classification using Genetic Algorithm and Fuzzy rule based System (GAFs) in order to reduce the complexity and also performance improvement. Experiment results showed that genetic algorithm as a training technique improves the fuzzy rule based parameters for facial expression recognition. To evaluate the system performance, images from Cohn-Kanade database were used and the accuracy rate of 92 % was obtained.

Table 1: Overall experiment results.

Total Number of Subjects	40
Number of training images	120
Number of test images	40
Classifier Method	Fuzzy-Genetic
Number of Emotions	4
Number of facial points	15
Parent selection function	Rolette wheel
Crossover operation	Two points for each parameter
Mutation probability	0.1
Best Accuracy result using Fuzzy-Genetic algorithm in the test phase	92%

In figure 2 and figure 3, the shapes of first extracted feature (f1) in before and after of training process by GA are shown.

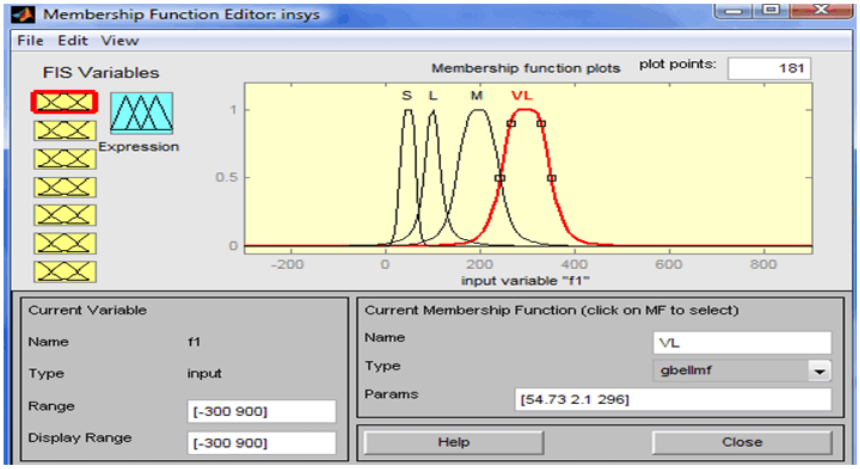

Fig. 2: Classic Membership Functions before training phase.

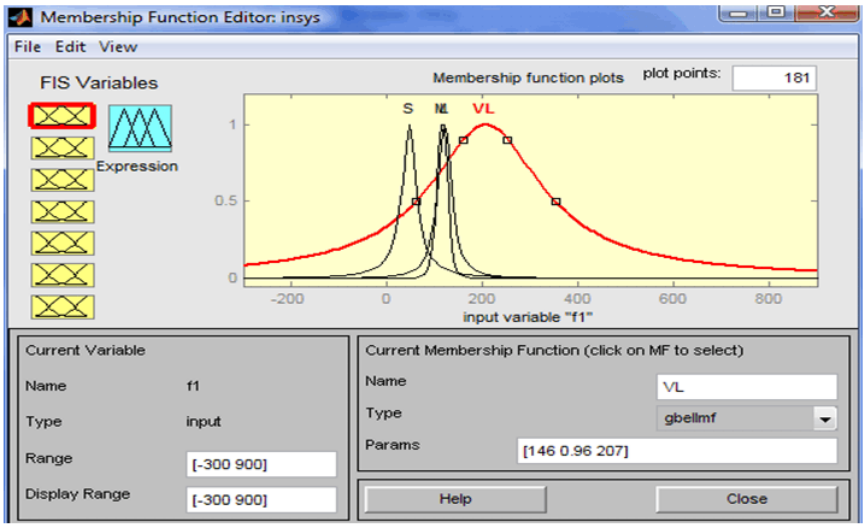

Fig. 3: Tuned Membership Functions by GA.

REFERENCES

Chen, X., T. Huang, 2003. Facial expression recognition: A clustering-based approach, Pattern Recognition Letters, 24: 1295-1302.

Cohen, I., N. Sebe, F. Cozman, M. Cirelo, T. Huang, 2003. Learning Bayesian network classifiers for facial expression recognition using both labelled and unlabeled data, in: Proc. of the 2003 IEEE CVPR.

Dubuission, S., F. Davoine, M. Masson, 2002. A Solution for facial expression representation and recognition, Signal Proccessing: Image Communication, 17: 657-673.

Ekman, P. and W.V. Friesen, 1978. The facial action coding system. Palo Alto, Calif. Consulting Psychologists Press.

Ebine, H., Y. Shiga, M. Ikeda and O. Nakamura, 2001. " Automatic Detection of Reference Face and The Recognition of Transition of Facial Expressions, Transactions of The Institute of Electrical Engineers of Japan, 121(10).

Fasela, B., J. Luettin, 2003. Automatic facial expression analysis: a survey, Pattern Recognition, 36: 259-275.

Geetha, A., V. Ramalingam, S. Palanivel, 2009. Facial expression recognition, A real time approach, Expert Systems with Applications, 36: 303-308.

Herrera, F., 2005. Genetic Fuzzy Systems: Status, Critical Considerations and Future Directions, International Journal of Computational Intelligence Research, 1(1).

Jamshidnezhad, A., Md. J. Nordin, 2011. A classifier model based on the features quantitative analysis for facial expression recognition, Proceeding of the International Conference on Advanced Science, Engineering and Information Technology, Malaysia.

Khanum, A., M. Muftib, M.Y. Javed, M.Z. Shafiq, 2009. Fuzzy case-based reasoning for facial expression recognition, Fuzzy sets and systems, 160: 231-250.

Kanad, T., J. Cohn and Y. Tian, 2000. Comprehensive database for facial expression analysis.

Lipori, G., [manual annotations of facial fiducial points], LAIV laboratory, University of Milan, web url: http://lipori.dsi.unimi.it/download.html.

Li Tian, Y., T. Kanade, J.F. Cohn, 1999. Recognizing Action Units for Facial Expression Analysis, Robotics Institute, Carnegie Mellon University, Pittsburgh, PA 15213.

Ma, L., K. Khorasani, 2004. Facial expression recognition using constructive feed forward neural networks, IEEE Trans. Syst. Man Cybern.

Susskind, J.M., G. Littlewort, M.S. Bartlett, J. Movellan, A.K. Anderson, 2007. Human and computer recognition of facial expressions of emotion, Neuropsychologia, 45: 152-162.

Seyedarabi, H., A. Aghagolzadeh, S. Khanmohammadi, Recognition of Six Basic Facial Expressions by Feature-Points Tracking using.

Pardàs, M., A. Bonafonte, J. Landabaso, 2002. Emotion recognition based on MPEG4 facial animation parameters, in: Proceedings of IEEE ICASSP.

Xiang, T., M.K.H. Leung, S.Y. Cho, 2008. Expression recognition using fuzzy spatio-temporal modeling, Pattern Recognition, 41: 204-216.