

PCA + LDA Fuzzy Based Model for Emotional Nature Recognition of Human Video



Dhiren Pandit, Jayesh Dhodiya

Abstract: Human expresses their emotions by means of verbal and nonverbal communication. Nonverbal communications are done mainly using facial expression. This paper aims to recognize human emotion using nonverbal communication of human facial expressions. Different mathematical techniques like: principle component analysis (PCA), linear discriminate analysis (LDA) and independent component analysis (ICA) are widely used for human facial expression recognition. This paper applied fusion of PCA and LDA based model for facial video emotion recognition with neural network (NN), fuzzy approach and Ekman's proposed concept of action units of faces. Moreover, results obtained in linguistic form using action units with fuzzy approach on unknown individual persons for identification of nature of input video and compare with the actual data to validate the model. This paper concludes that developed approach provides 99% accuracy for human facial expression recognition and identification of nature of input video.

Index Terms: Action units, Fuzzy approach, LDA, Neural network, PCA.

I. INTRODUCTION

Currently human communicates in verbal and non-verbal ways. Non-verbal communication includes facial expressions, hand gestures and voice tone to articulate emotion and provide opinion. Though a development of human-computer interfaces that provides system for automated recognition of speech but could not result in to natural interaction. If these emotional inputs recognition capacity available to computers, it would give exact and suitable help to human in ways that fulfil the need and preferences of the user. According to the psychological study the feeling of human can be categorize into 6 standard emotions: fear, happiness, anger, surprise, sadness and disgust [1]. Emotion expressed by face arise through changes in facial muscles and speech tones, that produced by applying the variation in production of speech, play a key role in convey above mentioned emotions and to communicate different feelings[2]. These signals can be identified even they are expressed finely which are processed by the information derived through hearing and visualization.

Psychological studies suggest that image information transforms opinion of speech [3] and hence likely to presume that person emotion acuity go after a parallel style. In view of this De Silva et al. designed the experiment in which 18 candidates have to distinguish emotion by means of image and audio information individually from an audio-visual catalogue recorded from two objects [4]. He proved that certain feelings like sadness and fear are superior recognized with audio and rest like anger and happiness are through video. Many systems have discovered for automatic recognition of emotion using expression of faces [5],[6],[7],[8], or speech to identify human emotional states, however less works are done towards the recognition of emotion using both modalities [9]. Here implementation of fusion approaches is done in terms of fuzzy evaluations of the overall scenario and analyze and recognize four human emotions like anger, happiness, neutral state and sadness, using a database which is pre-recorded[10].

II. PCA+LDA BASED MODEL FOR SINGLE PERSON VIDEO EMOTION RECOGNITION USING FUZZY SETS

A model for Human's facial expression recognition is presented here in figure 1.

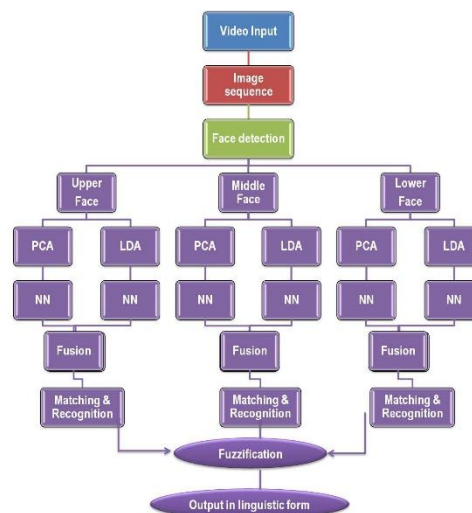


Fig. 1 Model for emotion recognition with fuzzy approach

It is done through modified fuzzy grade sheets. Modified fuzzy grade sheet is an array containing three columns and n rows, where n is total number of criterion. Here different facial expressions like Happy, Sad, Angry and Neutral etc. as criterion are considered.

Manuscript published on 30 September 2019

* Correspondence Author

Dr. Dhiren Pandit*, Dept. of Mathematics & Humanities, Institute of Technology, Nirma University, Ahmedabad, Gujarat, India.

Dr. Jayesh Dhodiya, Applied Mathematics & Humanities Department, SVNIT, Surat, Gujarat, India

Third Author name, His Department Name, University/ College/ Organization Name, City Name, Country Name.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license <http://creativecommons.org/licenses/by-nc-nd/4.0/>

The method which is followed in evaluation process and used to evaluate person’s emotion using facial expression is Fuzzy Evaluation Method. The procedure for emotion recognition using this model is described with following levels. In level 1 given video sequence is divided in sequence of face images at regular time interval. Here each face image is divided in three parts called Upper Face, Middle face and Lower face [11]. At level 2, recognition of action units is done for each part of human face using PCA+LDA+NN method [12]. For recognition using PCA, k eigen vectors corresponding to k largest eigen values of scatter matrix $S = \sum_N (X_i - \bar{X})(X_i - \bar{X})^T$, where \bar{X} is average face among all face images X_i taken and neural network is used for classification. For LDA first scatter matrix is computed and PCA is implemented for dimensionality reduction. Then Non-singular scatter matrices S_W (within class scatter) and S_B (between class scatter) are calculated. $S_B = \sum_C N_i (CA_i - \bar{X})(CA_i - \bar{X})^T$ and $S_W = \sum_C \sum_{X_i} N_i (X_K - CA_i)(X_K - CA_i)^T$ where number of dissimilar classes is C , number of images for each class i is N_i , average face image of faces in class i is CA_i , face images in class i are X_i , and \bar{X} is the average face image for all images in the dataset and then feature vectors calculated [13][14]. Again classification is done using neural network. Then score-based strategy is used for fusion of PCA and LDA [12]. At level 3 considerations of Upper face, middle face and lower face as criterion C1, C2 and C3 are done. Presume there are five satisfaction levels to appraise the Human’s facial expression Very good, good, normal, bad and very bad, where five satisfaction levels and its corresponding degrees of satisfaction are given in Table 1.

Table 1. Satisfaction Level with Amount of Satisfaction

Satisfaction Level(Xi)	Range of Degree of satisfaction	Maximum value for Degree of satisfaction(F(Xi))
Very Bad	0 to 0.19	0.19
Bad	0.2 to 0.39	0.39
Normal	0.4 to 0.59	0.59
Good	0.60 to 0.79	0.79
Very Good	0.8 to 1	1

Table 2. Normalized Values of Criteria

Criteri on	Total no of Images	Recogni zed images	Normaliz ed value
C1	m_1	r_1	m_1/r_1
C2	m_2	r_2	m_2/r_2
C3	m_3	r_3	m_3/r_3
C4	m_4	r_4	m_4/r_4
:	:	:	:
Cn	m_n	r_n	m_n/r_n

Let X be a set of satisfaction levels, $X = \{\text{Very good(V G), good(G), normal(N), bad(B), very bad(VB)}\}$ and let F be a mapping function which maps a satisfaction level to the maximum degree of satisfaction of the corresponding satisfaction level, where $F: X \rightarrow [0; 1]$. It can be seen that $F(\text{very good}) = 1.00$ (i.e. $F(\text{V G}) = 1.00$), $F(\text{good}) = 0.79$ (i.e. $F(\text{G}) = 0.79$), $F(\text{normal}) = 0.59$ (i.e. $F(\text{N}) = 0.59$), $F(\text{bad}) = 0.39$ (i.e. $F(\text{B}) = 0.39$), $F(\text{very bad}) = 0.19$ (i.e. $F(\text{VB}) = 0.19$).

At level 4, number of recognized images in each criterion is transformed into normalized values which lie in limit of 0 to 1. For each normalized value, number of images is divided by number of all images to attain the normalized value. For further evaluation, obtained normalized value will be the input value. At level 4 Construction is done for chart of the Fuzzy Membership Function. To execute fuzzification process the chart of membership function is developed. Using triangular membership function fuzzy membership value is obtained by mapping normalized value into chart of member ship function. Obtained membership value will signify level of satisfaction. This paper intends five satisfaction levels which were given in Table 1. The measure of satisfaction represents limit of number of images for each satisfaction stage. The highest amount of gratification symbolized by $F(X_i)$ portray a mapping function for equivalent gratification level, where $F(X_i)$ lies in 0 and 1. $F(X_i)$ denotes a mapping function which represents greatest quantity of satisfaction for the same satisfaction level. Here triangular membership

$$\text{function is } \mu_A(x) = \begin{cases} 0; & x < a, \\ \frac{x-a}{b-a}; & a \leq x \leq b, \\ \frac{c-x}{c-b}; & b \leq x \leq c, \\ 0; & x > c, \end{cases}$$

At level 5 calculations for final value of emotion is done. The final value for kth emotion denoted by $T(S_k)$ is evaluated as $T(S_k) = \frac{w_1 * D(C_1) + w_2 * D(C_2) + w_3 * D(C_3) + \dots + w_n * D(C_n)}{w_1 + w_2 + w_3 + \dots + w_n}$

Where $D(C_j) = \frac{y_1 * F(X_1) + y_2 * F(X_2) + y_3 * F(X_3) + \dots + y_9 * F(X_9)}{y_1 + y_2 + y_3 + \dots + y_9}$ is amount of satisfaction, where $y_i \in [0,1]$, for $i = 1, 2, 3, \dots, 9$ is quantity of membership value for each satisfaction level and w_i is total weightage of ith criteria for $i = 1, 2, 3, \dots, n$.

The result obtained is put into the fuzzy grade sheet in the appropriate columns. Fuzzy model is applied once PCA+LDA+NN based model with facial action coding system [15] identify emotion for single person video emotion analysis.

III. EXPERIMENTAL ANALYSIS FOR EXPRESSION RECOGNITION USING FUZZY APPROACH

In this paper implementation of PCA+LDA based Model for single person video emotion recognition using fuzzy sets is implemented. For this video of single persons of 22 minutes is taken in which different expressions of person are measured. First given video is converted in to sequence of images by using Matlab. Here input video is converted to sequence of images at an interval of 2 minutes and hence 11 images within given time period are obtained including image at time $t = 0$. After getting these 11 images john viola algorithm for face detection is used to obtain face images. This step will identify all faces from given image and then cropping and resizing techniques are applied for getting facial image. Then normalization techniques like gamma correction, histogram equalization are implemented for enhancement of facial image. Once normalization process is complete each face image is divided in three different portions called lower, middle and upper as Lower face, Middle face and Upper face as directed in figure 2.



Here for each image there will be three images. Hence at particular time instance three images are obtained. First consider only upper face images at all-time instances. Principle features are extracted by using principle component analysis (PCA) and linear discriminate analysis (LDA). Along with PCA and LDA neural network is used for classification purpose. For upper face image principle components using PCA and LDA are obtained. Then neural network is used for classification of upper face image in any one of the class like Happy, Angry, Sad or neutral. Same procedure is applied for middle face image and lower face image for recognition of different facial expressions. For recognition, facial action coding system is used [15]. For single person image each portion is classified using PCA+LDA+NN method. Hence resulting three answers are classified using fuzzy based model. Here score based technique is used for recognition of expression at particular time. Fuzzy based model is used for linguistic classification of nature of given human face video. When video of person 1 is passed, it is divided in sequence of images at an interval of 2 minutes. Each image is divided in three parts called Upper face, Middle face and lower face. We consider these three as criterion C1, C2 and C3. Table 3 shows emotion recognition of face images at different time instances for lower, middle and upper face. At next step number of recognized images is converted into normalized values discussed earlier and it is given in table 4.

Table 3. Recognition of face images at different time

Time	Lower				Middle				Upper			
	H a p p y	Sa d	A n g r y	N e u t r a l	H a p p y	Sa d	A n g r y	N e u t r a l	H a p p y	Sa d	A n g r y	N e u t r a l
0	1	0	0	0	1	0	0	0	1	0	0	0
1	0	0	1	0	0	0	1	0	1	0	0	0
2	0	0	0	1	1	0	0	0	0	0	0	1
3	0	0	0	1	0	0	0	1	0	0	0	1
4	0	1	0	0	0	1	0	0	0	1	0	0
5	0	1	0	0	0	1	0	0	0	1	0	0
6	0	1	0	0	0	1	0	0	0	1	0	0
7	1	0	0	0	1	0	0	0	1	0	0	0
8	1	0	0	0	1	0	0	0	1	0	0	0
9	1	0	0	0	1	0	0	0	1	0	0	0
10	1	0	0	0	1	0	0	0	1	0	0	0

Table 4. Fuzzy grade sheet for overall fuzzy values

Emotion	Criteria	Total no. of images	Recognize Images	Normalize Value
Happy	Upper face(C ₁)	11	6	0.55
	Middle face (C ₂)	11	6	0.55
	Lower face(C ₃)	11	5	0.46
Sad	Upper face(C ₁)	11	3	0.27
	Middle face (C ₂)	11	3	0.27
	Lower face(C ₃)	11	3	0.27
Angry	Upper face(C ₁)	11	0	0

	Middle face (C ₂)	11	1	0.09
	Lower face(C ₃)	11	1	0.09
Surprise	Upper face(C ₁)	11	2	0.18
	Middle face (C ₂)	11	1	0.09
	Lower face(C ₃)	11	2	0.18

Construction of fuzzy membership function:

For implementation of fuzzification process, triangular membership function is developed. This paper propose proposes five satisfaction levels which are shown as follows

$$\mu_{1(VB)}(x) = \begin{cases} 0; & x < 0, \\ 1; & 0 \leq x \leq 0.2, \\ \frac{0.4-x}{0.4-0.2}; & 0.2 \leq x \leq 0.4, \\ 0; & x > 0.4, \end{cases}$$

$$\mu_{2(B)}(x) = \begin{cases} 0; & x < 0.2, \\ \frac{x-0.2}{0.4-0.2}; & 0.2 \leq x \leq 0.4, \\ \frac{0.6-x}{0.6-0.4}; & 0.4 \leq x \leq 0.6, \\ 0; & x > 0.6, \end{cases}$$

$$\mu_{3(N)}(x) = \begin{cases} 0; & x < 0.4, \\ \frac{x-0.4}{0.6-0.4}; & 0.4 \leq x \leq 0.6, \\ \frac{0.8-x}{0.8-0.6}; & 0.6 \leq x \leq 0.8, \\ 0; & x > 0.8, \end{cases}$$

$$\mu_{4(G)}(x) = \begin{cases} 0; & x < 0.6, \\ \frac{x-0.6}{0.8-0.6}; & 0.6 \leq x \leq 0.8, \\ \frac{1-x}{1-0.8}; & 0.8 \leq x \leq 1, \\ 0; & x > 1, \end{cases}$$

$$\mu_{5(VG)}(x) = \begin{cases} 0; & x < 0.8, \\ \frac{x-0.8}{1-0.8}; & 0.8 \leq x \leq 1.0, \\ 1 & x > 1 \end{cases}$$

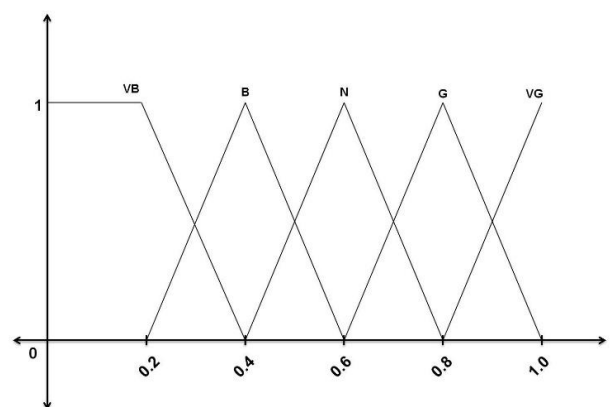


Fig. 2 Triangular fuzzy membership function

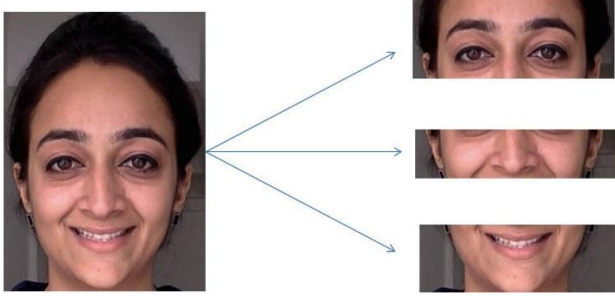


Fig. 3 Face Image division in three parts (UF, MF, LF)

Based on triangular fuzzy membership function we can see the degree of gratification of normal and good signify the quantity of membership y_i and y_j respectively. The amount of Degree of satisfaction for happy criteria

$$D(C_1) = \frac{0.3 * 0.4 + 0.7 * 0.6}{0.4 + 0.6} = 0.54$$

Same way $D(C_2)$ and $D(C_3)$ are calculated. Similarly, degree of satisfaction for all criterions is calculated for all emotion namely sad, angry and neutral. Here we have considered weightage of upper face $w_1 = 0.25$, middle face $w_2 = 0.25$ and lower face $w_3 = 0.5$ and final value for emotion happy is calculated as

$$T(S_{Happy}) = \frac{0.25 * 0.54 + 0.25 * 0.54 + 0.5 * 0.45}{25 + 25 + 50} = 0.495$$

Similarly, final values for other emotions can be calculated which is mention in table 5.

Table 5. Results from fuzzy model.

Em o-tion	Criteria	Very bad (VB)	Bad (B)	Nor mal (N)	Go od (G)	Ve ry Go od (V G)	Degree of Satisfac-tion (D(C _i))	Fin-al Va-l ue (F(S i))
Hap-py	Upper face(C ₁)	0	0.3	0.7	0	0	0.54	0.495
	Middle face (C ₂)	0	0.3	0.7	0	0	0.54	
	Lower face(C ₃)	0	0.7	0.3	0	0	0.45	
Sad	Upper face(C ₁)	0.65	0.35	0	0	0	0.26	0.26
	Middle face (C ₂)	0.65	0.35	0	0	0	0.26	
	Lower face(C ₃)	0.65	0.35	0	0	0	0.26	
Ang-ry	Upper face(C ₁)	1	0	0	0	0	0.19	0.19
	Middle face (C ₂)	1	0	0	0	0	0.19	
	Lower face(C ₃)	1	0	0	0	0	0.19	
Sur-p-ri-se	Upper face(C ₁)	1	0	0	0	0	0.19	0.19
	Middle face (C ₂)	1	0	0	0	0	0.19	
	Lower face(C ₃)	1	0	0	0	0	0.19	

IV. RESULTS

Fuzzy logic has been recognized as an effective tool to deal with the vagueness involved in the data. This paper finds emotion level in each of individual using PCA+LDA method with classification using neural network with fuzzification process. The results obtained by method of PCA+LDA using

neural network and facial action coding system with fuzzy model are shown as follows.

1. For happy emotion final value is 0.495 which can be interpreted in linguistic form as “it is normal at 0.475 and bad at 0.525.
2. For angry emotion final value is 0.26 which can be interpreted in linguistic form as “it is very bad at 1.0.
3. For sad emotion final value is 0.19 which can be interpreted in linguistic form as “it is very bad at 1.0.
4. For neutral emotion final value is 0.19 which can be interpreted in linguistic form as “it is very bad at 1.0.

In this fuzzy evaluation model, fuzzy membership values are used for computation, which are in range of 0 to 1 and therefore the results gained from this method are in the range of 0 to 1only. These values are converted in percentages for adaptation. Thus the first emotion (Happy) of 0.495 becomes 49.50% percentage after the conversion. Hence it can be concluded that given video is classifying in happy, bad with 52.5% and normal at 47.5%.

V. CONCLUSION

From this paper it can be concluded that PCA+LDA base method with classification using neural network along with facial action coding system and fuzzy based method gives 99% accuracy for human facial expression recognition and identification of nature of input video. It gives reliable results with real time data.

REFERENCES

1. U.M Prakash, Pratyush, Pranshu Dixit and Anamay Kumar Ojha, “Emotional Analysis Using Image Processing”, International Journal of Recent Technology and Engineering, Volume-7 Issue-5S2, 2019, pp. 258-262
2. Naga Raju Katta and M. Babu Reddy, “Facial Expression Recognition Using Local Positive Directional Pattern (LPDP)”, International Journal of Recent Technology and Engineering, Volume-7, Issue-6S, 2019, pp. 61-70
3. Mase K. “Recognition of facial expression from optical flow”. IEICE Transc, 74(10) (1991):3474–3483
4. De Silva, L. C., Miyasato, T., and Nakatsu, R. “Facial Emotion Recognition Using Multimodal Information”. In Proc. IEEE Int. Conf. on Information, Communications and Signal Processing (ICICS’97), Singapore (1997): 397-401.
5. Black, M. J. and Yacoob, Y. “Tracking and recognizing rigid and non-rigid facial motions using local parametric model of image motion”. In Proceedings of the International Conference on Computer Vision, IEEE Computer Society, Cambridge, MA (1995): 1374–381
6. Essa, Pentland, A. P. “Coding, analysis, interpretation, and recognition of facial expressions”. IEEE Transc. On Pattern Analysis and Machine Intelligence, 19(7) (1997):757–763
7. Lee, C. M., Yildirim, S., Bulut, M., Kazemzadeh A., Busso, C., Deng, Z., Lee, S., Narayanan, S.S. “Emotion Recognition based on Phoneme Classes”. to appear in Proc. ICSLP’04 (2004)
8. Shyi-Ming Chen, Chia-Hoang Lee. “New methods for students’ evaluation using fuzzy sets” Fuzzy sets and systems, Elsevier, 104 (1999): 209-218
9. De Silva, L.C., Ng, P. C. “Bimodal emotion recognition Automatic Face and Gesture Recognition”, 2000. Proceedings. 4th IEEE International Conference on, 28-30 March (2000). 332 – 335.
10. Massaro, D. W. “Illusions and Issues in Bimodal Speech Perception”. Proceedings of Auditory Visual Speech Perception, Terrigal-Sydney Australia (1998): 1-26
11. Tian, Ying-li, Kanade, T. and Cohn, J. “Recognizing Lower Face Action Units for Facial Expression Analysis”. Proceedings of the 4th IEEE International Conference on Automatic Face and Gesture Recognition (FG’00), (2000): 484 – 490



12. A.Jothimani, Parimi Prasanth, Shradha Anil and J.Arun Nehru, "Facial Expression for Emotion Detection using Deep Neural Networks" International Journal of Recent Technology and Engineering, Volume-8 Issue-1S2, 2019, pp. 242-248
13. Changjun Zhou, Lan Wang, Qiang Zhang, Xiaopeng Wei. "Face recognition based on PCA image reconstruction and LDA." Optik - International Journal for Light and Electron Optics, Volume 124, Issue 22, (2013): 5599-5603.
14. Jian Yang, Jing-yu Yang. "Why can LDA be performed in PCA transformed space", Pattern Recognition, Biometrics, Volume 36, Issue 2, (2003): 563-566
15. Ekman P., Friesen WV., "The Facial Action Coding System: A Technique for the Measurement of Facial Movement." Consulting Psychologists Press, San Francisco (1978).

AUTHORS PROFILE



Dr. Dhiren Pandit, is Ph.D. in Mathematics from SVNIT Surat, Gujarat, M. Phil. From Veer Narmad South Gujarat University, Surat and M.Sc. from The M.S. University, Baroda, Gujarat. He has published several research papers in peer reviewed International Journals. He has teaching experience of around 14 years at UG and PG level. His research interest

includes Digital Image Processing, Machine learning and Deep learning.
Current affiliation: Assistant Professor, Institute of Technology, Nirma University, Gujarat



Dr. Jayesh Dhodiya: Currently working as an associate professor at SVNIT, Surat. He is devoted to general research on advance operation research, optimization technique, mathematical modeling and simulation knowledge based system, data mining. His research has been published in journals such as Journal of Science,

Journal of Management, Management World and Journal of Operation Research. He has completed four Research and Development project with IBM. He is author and co-author of several papers in journals and proceedings. He received so many best paper award and get gold medal in his M.Sc. Program. He has given expert talk at various places and also organized conferences/workshops/seminars/techfests. He has SRM membership, Society of Special Function membership, Gujrat Ganit Mandal membership and Indian Mathematical Society membership.