International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:8, No:6, 2014

Curvelet Features with Mouth and Face Edge Ratios for Facial Expression Identification

S. Kherchaoui, A. Houacine

***Abstract*—**This paper presents a facial expression recognition system. It performs identification and classification of the seven basic expressions; happy, surprise, fear, disgust, sadness, anger, and neutral states. It consists of three main parts. The first one is the detection of a face and the corresponding facial features to extract the most expressive portion of the face, followed by a normalization of the region of interest. Then calculus of curvelet coefficients is performed with dimensionality reduction through principal component analysis. The resulting coefficients are combined with two ratios; mouth ratio and face edge ratio to constitute the whole feature vector. The third step is the classification of the emotional state using the SVM method in the feature space.

***Keywords*—**Facial expression identification, curvelet coefficients, support vector machine (SVM).

I. Introduction

ACCORDING to the dictionary, emotion is a transitory affective response with a large intensity; usually caused by a stimulus coming from the environment. The detection of the emotional state of a person or the identification of the facial expressions (facial expression recognition FER) is not an easy task. There is a number of difficulties due to the variability of the expressions through human populations and the surrounding contexts for the same individuals. Generally face expression recognition systems are based on three parts:

1. Detection and localization of faces.
2. Facial feature extraction.
3. Classification of facial expressions and identification of the emotional states.

Face detection has been addressed by several researchersand by various methods such as neural networks [1], [2], using the invariable characteristics such as skin color or facial features extraction. The facial features are expected to reflect the most appropriate image representation for the face identification and interpretation of the emotional states.

Since the early 70s Paul Ekman and his colleagues have conducted extensive studies on expression field [11] and established its universality.

They defined seven basic expressions (joy, fear, surprise, disgust, sadness, anger, and neutral). Ekman and Freisen [12] have developed the Facial Action Coding System “FACS” described by 44 units of action coding. These actions do not contain emotion but just their identification through other systems. Ekman is considered the godfather of the identification of facial expressions.

There are two main approaches for the facial expression identification; the holistic approach [4], where template matching is used, and the geometric approach based facial features [3]. In holistic approaches, the template can be pixel based where a feature vector is generally obtained after the processing of the face image, followed by principal component analysis and the multilayer neural networks. SVM are also widely used for classification step [3], [8].

The geometric approach systems exploit the main components of the face where the characteristic points are detected. Distances between characteristic points are calculated to form the feature vectors or build a model of appearance [6], [7], [9], [10], [13]. The system presented here belongs to the holistic approach.

II. Facial Expression Identification System

The FER system presented here is divided into three parts:

1. Face and facial features detection.
2. Normalization and features extraction.
3. Facial expression classification by SVM classifier

A. Face and Facial Features Detection

The system described below is designed to identify seven basic facial expressions which are: joy, fear, surprise, disgust, sadness, anger, and neutral expressions. Face and facial feature detection (eyes and mouth) is performed according to the Viola and Jones method [4].

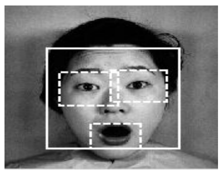

Fig. 1 Face and facial features localization

1) Extracting the Region of Interest

The aim of this part is to center the face area around the facial features detected. We have localised the eyes and the mouth then we determine the boundary of the centered face following the higher and lower area limits of eyes and mouth as follows:

$$Upper\ Lim = (lim\ left\ eye\ up + lim\ right\ eye\ up)/2 \\ -(left\ eye\ width + right\ eye\ width)/2 - cst$$

Cst is an experimentally determined value.

S. Kherchaoui and A. Houacine are with the LCPTS Faculty of Electronics and Informatics USTHB, BP32 El Alia, Bab Ezzouar, Algers, Algeria (e-mail: ainos04@yahoo.fr, ahouacine@usthb.dz).

$$Left\ lim\ =\ left\ \lim\ of\ left\ eye.$$
$$Right\ lim = right\ lim\ of\ right\ eye.$$
$$Lower\ lim = lower\ lim\ mouth\ + (mouth\ width\ /2)$$

Fig. 2 Face centered region

2) Normalization of Centered Face Image

The interest region detected is normalized by a standard nearest neighbor interpolation to areas of size 60 by 60 pixels. Curvelet coefficient decomposition is then applied to the normalized interest region.

3) Curvelet Transform

Curvelet transform [4] is a kind of multi-resolution analysis tool. Emmanuel J. Candès and David Donoho [16], [15], proposed it in 1999. It has gone through two major revisions. The first one is commonly referred as the “Curvelet99” now, and its performance is relatively slow. The latest version is the second curvelet generation transform proposed in 2002.

The curvelet transform attracted the researchers widely after being proposed. And, the publication of a digital curvelet transform implementation accelerated its development. The continuous curvelet transform of a function *f* can be expressed as follows:

$$c(j, l, k) := < f , \varphi\, j, l, k > \tag{1}$$

where $\varphi\, j, l, k$ is the curvelet, *j*, *l*, *k* are respectively the scale, direction and position parameters of the curvelet transform implemented in the frequency domain.

The discrete curvelet transform analougous to (1) is as follows :

$$C(j,l,k) = \sum_{0\le t_1,t_2<n} f[t_1,t_2].\overline{\varphi_{J,l,k[t_1,t_2]}} \tag{2}$$

For our system we used Donoho and Candes version, alias the second generation, of curvelets [15]-[16], where we find two implementations available [14]. The first method is based on USFFT: unequally-spaced Fast Fourier Transform while the second is based on a "package (warping) well-selected samples of the Fourier transform that we used for our system. We apply discrete curvelet transform of [14] and we consider all coefficients for the fourth level.

4) Principal Component Analysis (PCA)

Principal component analysis (PCA) is a conventional statistical tool that applies an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The PCA is widely used in image processing. The number of obtained curvelet coefficients for each image is very high. Then, PCA is applied for dimensionality reduction. PCA is first applied to each curvelet subband coefficients. The selected coefficients are arranged as a vector of features.

5) Mouth and Face Edge Ratios

We have already localized the mouth and the centred face region. In this step we calculate tow ratios.

a) Mouth Ratio

Mouth ratio is the ratio of its width top height. First we apply the canny edge detector to extract all edges of the mouth then we determine the height and width with four pointer: up, down, right and left.

Fig. 3 Mouth edges

b) Face Edge Ratios

The facial expression changes with emotion. The face translates these variations by wrinkles. For this, we use the Canny edge detector on the face centred image and a threshold is applied to localize all wrinkles. Then we calculate the ratio between the white and black pixels as shown in the Fig. 4.

Face edge ratio and mouth ratio are added to the feature vector of selected curvelet coefficients to be used for classification.

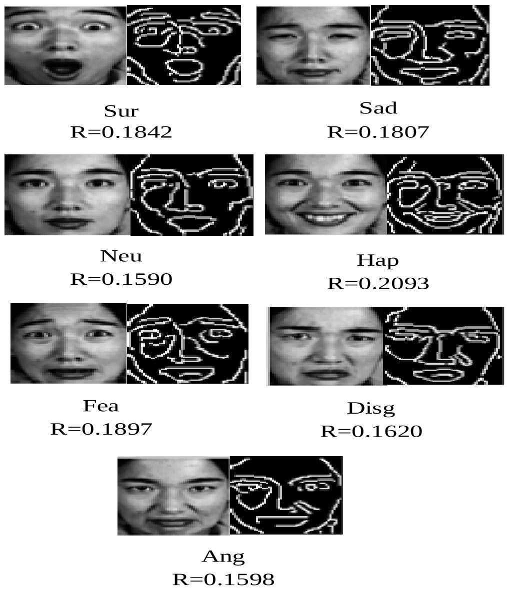

Fig. 4 Face edge ratios for the seven states

III. RESULTS

For training and evaluation of the system we used the JAFFE (Japanese Female Facial Expression) Database [5]. This database contains 213 face images with seven facial expressions six bases more neutral expression. The 213

International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:8, No:6, 2014

images represent ten Japanese women, hence the database name used.

We explore the effectiveness of the system presented in this paper by identifying the seven base facial expressions. We used 139 images from the database for training, with a mean of two images for each state for each subject, and 74 images for testing. We considered two images per state for each subject.

TABLE I
CONFUSION MATRIX

State	Ang	Digu	Fear	Happ	Neut	Sad	Surp
Ang	10	0	0	0	0	0	0
Digu	0	8	0	0	0	1	0
Fear	0	1	11	0	0	0	0
Happ	0	0	0	11	0	0	0
Neut	0	0	0	0	11	0	1
Sad	0	0	0	0	0	10	0
Surp	0	0	0	0	0	0	10

Fig. 5 Examples of true facial expression identification

The correct identification rate of facial expressions is 95.95%. The best rate is for the anger and happy expression with 100% accuracy.

The tests were carried out on an i5-3210M machine and the execution time is of 2.364 seconds.

IV. CONCLUSION

The system presented in this article gives a very encouraging identification rate with a very interesting processing time that allows its use in real time. It offers a good compromise between the rate of correct identification of facial expressions and the execution time.

Considering other databases in the future to overcome the limitations of JAFFE database is planned. We may also think in defining different geometric features to combine with the curvelet coefficients to improve the results. The performance of this system depends however on the method used for detecting facial features.

REFERENCES

[1] H. Rowley, S. Baluja, and T. Kanade, “Human face detection in visual scenes”, Technical Report CMU-CS-95-158R, School of Computer Science, Carnegie Mellon University, Nov. 1995.

[2] K.-K. Sung and T. Poggio, “Example-based learning for view-based human face detection”, Technical Report A.I. Memo 1521, CBCL Paper 112, MIT, Dec. 1994.

[3] M. Pantic and L. J. M. Rothkrantz, “Expert Ststem For Automatic Analysis Of Facilal Expressions”, Image And Vision Computing 18, pp.881-905, 2000.

[4] P.Viola, M.Jones, “Robust Real Time Object Detection”, Second International Workshop on Statistical and Computational Theories of Vision Modelling, Learning, Computing and Sampling, Vancouver, Canada, July 13, 2001.

[5] http://www.kasrl.org/jaffe.html

[6] Xianxing Wu, Jieyu Zhao, “Curvelet Feature Extraction for Face Recognition andFacial Expression Recognition”, Sixth International Conference on Natural Computation, 2010.

[7] T. F. Cootes, G. J. Edwards and C. J. Taylor. “Active Appearance Models”, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 23, N° 6, 2001.

[8] D. Arumugan, S. Purushothaman, “Emotion Classification Using Facial Expression”, International Journal of Advanced Computer Science and Application, Vol. 2, N°7, 2011.

[9] M. S. Bartlett, Joseph C. Hager, P. Ekman, and T. J. Sejnowski, “Measuring facial expressions by computer image analysis”, Psychophysiology, Cambridge University, USA 36, pp.253–263, 1999.

[10] Zheng You, “Feature-Based Facial Expression Recognition: Sensitivity Analysis and Experiments with a Multi-Layer Perceptron”, International Journal of pattern Recognition and artificial Intelligence, 13(6), pp.893-911, 1999.

[11] P. Ekman, W.V. Friesen, “Facial action coding system: investigator’s guide”, Consulting Psychologists Press, Palo Alto, CA, 1978.

[12] P.Ekman. Strong evidence of universals in facial expressions: A reply to Russell’s mistaken critique. Psychological Bulletin, pp. 268-287, 1994.

[13] AshirbaniSaha, Q.M. Jonathan Wu, “Facial expression recognition using curvelet based local binary patterns”, ICASSP, 2010.

[14] www.curvelet.org.

[15] D. L. Donoho and M. R. Duncan, “Digital curvelet Transform: Strategy, Implementation, Experiments”, Technical Report, Stanford University, 1999.

[16] E. Candés, L. Demanet, D. Donoho and L. Ying, “Fast Discrete Curvelet Transforms”, Applied and Computational Mathematics, Caltech, Pasadena, 2006.