The Facial Expression Recognition using the Inclined Face Geometrical information

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Abstract

The paper is facial expression recognition based on the inclined face geometrical information. In facial expression recognition, mouth has a key role in expressing emotions, in this paper the features is mainly based on the shapes of mouth, followed by eyes and eyebrows. This paper makes its efforts to disperse every feature values via the weighting function and proposes method of expression classification with excellent classification effects; the final recognition model has been constructed.

Key words

facial expression recognition, inclined face geometrical characteristics, facial expression feature, expression classification, real-time

Ⅰ. Introduction

Facial expression recognition have become one of the most active areas of pattern recognition, image analysis and understanding.[5]-[7] The problem of recognizing emotion from face is known to be very complex and difficult because individuality may not be ignored in expressing and observing emotions, the problem of recognizing facial expressions has recently been handled by various intelligent techniques, including artificial neural networks, fuzzy modeling approach using manually extracted distance based features,[8]-[10] Action Unit (AU) based approach using computer graphics model, and motion based approach using optical flow.[1]-[4]

Ⅱ. Facial Expression Recognition

2.1 Extraction of facial expression features

The effective extraction of the feature data is critical to recognize the expressions. In this paper the features is mainly based on the shapes of mouth, followed by eyes and eyebrows.

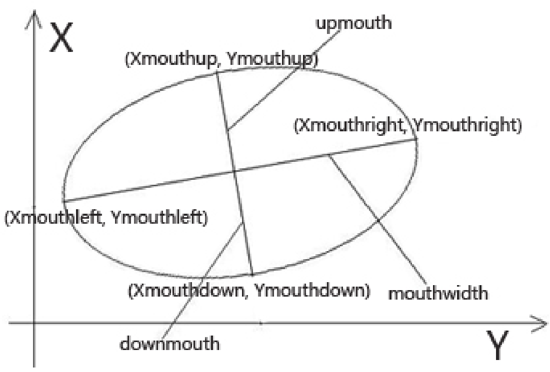

Fig. 1. Feature extraction of the mouth

The feature of the mouth is extracted and showed in fig. 1; the feature of the eyes and eyebrows is extracted, as shown in fig. 2.

In Fig. 1, this paper represents the value of the departure distance of the upper lip from the line between the two mouth corners with the vertical coordinate difference between the midpoints of the lip and the right mouth corner point, it is expressed as

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$upmouth$ of the upper lip, $mouthright$ of the right lip and the calculation equation is as follows:

$$upmouth = |Y_{mouthup} - Y_{mouthright}| \quad (1)$$

This paper represents the value of the departure distance of the lips from the line between the two mouth corners with the vertical coordinate difference between the bottom lips to the right mouth corner, it is expressed as $downmouth$ of the bottom lip, and the calculation equation is as follows:

$$downmouth = |Y_{mouthdown} - Y_{mouthright}| \quad (2)$$

And then it expresses the rate relation by the ratio of the up-mouth and down-mouth, by the value of $ratio$ can express the change of expression, for example, when someone is happy, the $upmouth$ is far smaller than the $downmouth$, while when someone is surprised, the difference between $upmouth$ and $downmouth$ is not obvious, the calculation equation of $ratio$ is as follows:

$$ratio = \frac{upmouth}{downmouth} \quad (3)$$

Actually, expression changes are also reflected at the opening degree of the entire mouth, generally, the mouth height expressed in surprise is larger than that at neutral expressions, this paper uses $|Y_{mouthup} - Y_{mouthdown}|$(the vertical coordinate difference of the midpoints of the up and down lips) and the mouth width to represent the entire opening degree of the mouth $WHratio$, the mouth width is $|X_{mouthleft} - X_{mouthright}|$calculated from the horizontal coordinate difference between the right mouth corner and the left mouth corner.

$$WHratio = \frac{|Y_{mouthup} - Y_{mouthdown}|}{|X_{mouthleft} - X_{mouthright}|} \quad (4)$$

By now, the two features of mouth, $ratio$ and $WHratio$, have been calculated.

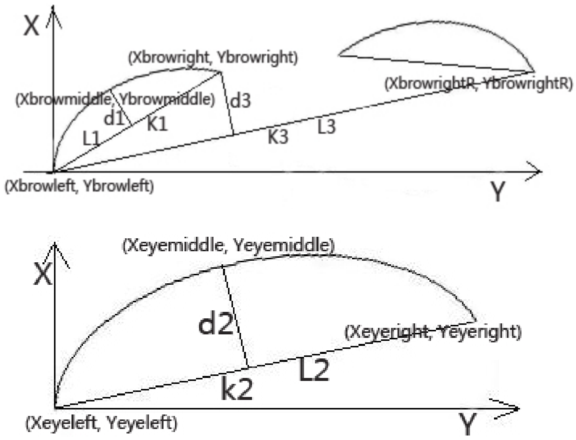

Fig. 2. Feature extraction of eyebrow and eye

Selection of eyes and eyebrows is mainly determined depending on the changes of the curve degrees of the eyebrows and the upper limb of the eyes when the human expressions change, as shown in Fig. 2, the slope of the alliance line L1 (the line L1 between eyebrow’s start-point and end-point) as K1 , the slope of the alliance line L2 (the line L2 between eye’s start-point and end-point) as K2 , the slope of the alliance line L3 (the line L3 between left eyebrow's start-point and right eyebrow's end-point) as K3 , $browshape$ is the ratio of the d1 (the d1 is Euclidean distance from the left eyebrow’s top edge midpoint to the L1) and the L1, $eyeshape$ is the ratio of the d2 (the d2 is Euclidean distance from the eye’s upper limb midpoint to the L2) and the L2, $browangle$ is the ratio of the d3 (the d3 is Euclidean distance from the left eyebrow's right endpoint to the L3) and the L1, this paper gets $browshape$, $eyeshape$, $browangle$ as extracting feature. For the operating simplify and the symmetry of the eyes and eyebrows, this paper extracts the features of the left eye and eyebrows only.

The calculation equation of slope K1, K2 and K3 is as follows:

$$K_1 = \frac{Y_{browleft} - Y_{browright}}{X_{browleft} - X_{browright}} \quad (5)$$

$$K_2 = \frac{Y_{eyeleft} - Y_{eyeright}}{X_{eyeleft} - X_{eyeright}} \quad (6)$$

$$K_3 = \frac{Y_{browleft} - Y_{browrightR}}{X_{browleft} - X_{browrightR}} \quad (7)$$

Among which, $(X_{browleft}, Y_{browleft})$is the coordinate of the left endpoint of the left eyebrow, $(X_{eyeleft}, Y_{eyeleft})$is the coordinate of the left endpoint of the eye, $(X_{browright}, Y_{browright})$is the coordinate of the left eyebrow's right endpoint, $(X_{browrightR}, Y_{browrightR})$is the coordinate of the right endpoint of the right eyebrow, $(X_{eyeright}, Y_{eyeright})$is the coordinate of the eye's right endpoint, $(X_{browmiddle}, Y_{browmiddle})$is the coordinate of the left eyebrow's top edge midpoint, $(X_{eyemiddle}, Y_{eyemiddle})$is the coordinate of the eye's upper limb midpoint. When the expression varies, for example, when someone smiles, the extension of eyes and eyebrows is relatively natural and smooth, while when someone is surprised, in most cases, the eyebrows slop upwards, when someone is in anger, and the eyebrows have a horizontal trend.

The liner equation of line L1 is:

$$y - K_1 \times x + K_1 \times x_1 - y_1 = 0 \quad (8)$$

Among which, $(x_1, y_1)$is the one endpoint coordinate of the left eyebrow.

The liner equation of line L2 is:

$$y - K_2 \times x + K_2 \times x_2 - y_2 = 0 \quad (9)$$

Among which, $(x_2, y_2)$is the one endpoint coordinate of the eye.

The liner equation of line L3 is:

$$y - K_3 \times x + K_3 \times x_3 - y_3 = 0 \quad (10)$$

Among which, $(x_3, y_3)$is the right endpoint coordinate of the right eyebrow.

The calculation equation of d1 is as follows:

$$d1 = \frac{|Y_{browmiddle} - K_1 \times X_{browmiddle} + K_1 \times x_1 - y_1|}{\sqrt{1+K_1^2}} \quad (11)$$

The calculation equation of d2 is as follows:

$$d2 = \frac{|Y_{eyemiddle} - K_2 \times X_{eyemiddle} + K_2 \times x_2 - y_2|}{\sqrt{1+K_2^2}} \quad (12)$$

The calculation equation of d3 is as follows:

$$d3 = \frac{|Y_{browright} - K_3 \times X_{browright} + K_3 \times x_3 - y_3|}{\sqrt{1+K_3^2}} \quad (13)$$

The calculation equation of the L1 is as follows:

$$L1 = \sqrt{(X_{browright} - X_{browleft})^2 + (Y_{browright} - Y_{browleft})^2} \quad (14)$$

The calculation equation of the L2 is as follows:

$$L2 = \sqrt{(X_{eyeright} - X_{eyeleft})^2 + (Y_{eyeright} - Y_{eyeleft})^2} \quad (15)$$

The calculation equation of is as follows:

$$browshape = \frac{d1}{L1} \quad (16)$$

The calculation equation of is as follows:

$$eyeshape = \frac{d2}{L2} \quad (17)$$

The calculation equation of is as follows:

$$browangle = \frac{d3}{L1} \quad (18)$$

The point coordinate $(X_{browright}, Y_{browright})$ are substituted into the formula $y - K_3 \times x + K_3 \times x_3 - y_3$, and the numerical calculation is given, $browangle$ take positive when calculation value more than 0, $browangle$ take negative when calculation value less than 0.

Thus the extraction of the feature values has been finished, and there are 3 feature points in eyebrows and eyes and 2 feature points from mouth. Therefore, there are 5 features in total.

2.2 Construction of feature function

Data in this paper after extracting expression features has a fine discrimination level. There are 5 dimensions in total, when the expression is smile, the discrimination of the first dimension is more obvious than the first dimension of other expressions, generally, and it can be directly distinguished from the first dimension. When the expression is surprise, this expression can also be distinguished from other expressions through the first and second dimensions, when the expression is neutral or angry; such expressions are generally calculated and distinguished by using all the 5 dimension data. To get the more dispersing data, it makes the all 5 dimensions' weights be unequal to every dimension and the product of the data its weight is more evident, this paper presents a new expression feature values weighting function to initialize the weights of every dimension, the calculation model is as follows:

$$w(n)\begin{cases}0.1 & n=5\\ w(n+1)+\ldots+w(5)+C & n=4,3,2,1;C>0\end{cases} \quad (19)$$

Weights of various dimension data set in this paper through models are as follows: when C=0.1, {1.6, 0.8, 0.4, 0.2, 0.1} may be got. Before analyzing and recognizing the data of every expression, this paper manually classified the expressions of the pre-assigned samples and then extracted the features by the system automatically, analyzed data, practices the sample cluster of every expression and analyzed the change trend of every expression data.

Following that, set up the interval (min, max) between the upper and bottom bounders for every dimension data of every expression in the practice sample cluster, so that to judge whether every dimension data of the expression which will be analyzed and tested falls in the practiced sample cluster. Identify the corresponding value of every dimension by using equation(20).

$$Range[Data[i],\min[i],\max[i]]=\begin{cases}1 & \min \le Data[i] \le \max\\ 0 & other\end{cases} \quad (20)$$

Among which, various data elements in $Data[i]$ refer to various dimension feature values calculated in section 2.1.

This paper uses the max value of the corresponding expression calculation results as the method to recognize the expressions. It has been mentioned above that there is obvious difference between various dimension data corresponding to a certain expression and the dimension data corresponding to another expression, so this paper fixing the corresponding weight of every dimension, while continuously adjust the value of the interval between the upper and bottom bounders of various dimension data, Through the recognizing results calculation model (21), it can get the sum of the product of every dimension's determinant value and the corresponding weight w, find the maximum value of the corresponding expression calculation results, so that to determine the arbitration of this expression.

$$\mathrm{Exp}=MAX_{i=1\ldots m}\left(\sum_{j=1}^{n}Range[Data[j],\min[i,j],\max[i,j]]\times w[j]\right) \quad 21)$$

Among which, $i=1\ldots m$ presents that there are m kinds of expressions in total, $\min[i,j],\max[i,j]$ represent the interval between the upper and bottom bounders of various dimension (dimension n) corresponding to every expression among the m kinds of expressions, this equation calculates and sums various dimensions of the same expression with the interval between the upper and bottom bounders of the m kinds of expressions, and then, draw the maximum value of the corresponding sum and get the corresponding expression.

By now, the interval of various dimension data, corresponding weighting optimization and the final results recognition model have been constructed.

III. Experiments and Analysis

3.2 Facial Expression Recognition

(a0)Surprise (b0) Smile (c0) Angry (d0) Nature
Fig. 3. Text image

We selected different facial expression images, Fig.3. as an example, extracted their feature components. Table1 shows the feature components of facial expression.

Table 1. Feature components of facial expression

	ratio	WHratio	browangle	browshape	eyeshape
(a0)	0.85	1.21	0.18	0.31	0.34
(b0)	0.41	0.43	0.13	0.27	0.23
(c0)	3.35	0.31	-0.15	0.13	0.25
(d0)	0.98	0.39	0.03	0.21	0.27

Set up the interval (min, max) between the upper and bottom bounders for every dimension data of every expression in the practice sample cluster, so that to judge whether every dimension data of the expression which will be analyzed and tested falls in the practiced sample cluster. Table2 shows the database information of facial expression.

Table 2. Database information of facial expression

	surprise	smile	angry	nature
ratioMin	0.73	0.35	2.55	0.88
ratioMax	0.87	0.49	4.15	1.15
WHratioMin	1.02	0.31	0.29	0.35
WHratioMax	1.31	0.46	0.55	0.43
browangleMin	0.15	0.08	-0.32	-0.05
browangleMax	0.21	0.20	-0.09	0.07
browshapeMin	0.26	0.15	0.07	0.13
browshapeMax	0.40	0.29	0.23	0.25
eyeshapeMin	0.28	0.13	0.18	0.25
eyeshapeMax	0.43	0.25	0.27	0.33

3.3 Experiment Result

In the facial expression recognition experiment, we shot 80 frontal face images via cameras as the target faces base, the recognition rate can also reach 83%, both have got an excellent recognition effects.

Table 3. Experiment result

	Recognition rate
Facial Expression Recognition	83%

IV. Conclusions

The research experiments mentioned in this paper indicate that the analysis and recognition to various expressions have achieved the predicated objective. In addition, expression recognition results of the experiment, results were satisfactory. The results of the relevant experiments show that it generally takes about 19-21ms from the preprocessing of the original images to expressions recognition results; it can fully satisfy the real-time requirements. In order to use this research, by analyzing the features of the face can be used as input parameters. In addition, the expression recognition of human-emotion that the use of avatars and robots.

References

[1] Dadong Zhao, Jeong-Young Song, A Study on the Face Expressive Recognition based on the Skin Color and the Face Geometric Characteristics. *Department of Computer Engineering Master Thesis*, PAI CHAI University, pp. 42-48, 2010.

[2] Dadong Zhao, Jeong-Young Song, A Study on the Face Recognition based on the Face Geometrical Characteristics[C]. Summer Academic Conference at Kyonggi University, pp. 21-27, 2010.

[3] Shukla, A.; Dhar, J.; Prakash, C.; Sharma, D.;Anand, R.K.;Sharma, S.;"Intelligent Biometric System using PCA and R-LDA,"Intelligent

Systems, GCIS '09,Vol.1, pp.267-272, 2009.
[4] David G. Lowe, "Distinctive Image Features From Scale-Invariant Keypoints," Accepted for publication in the International Journal of Computer Vision, 2004
[5] Zhizheng Liang, Youfu Li, Pengfei Shi, A note on two-dimensional linear discriminant analysis, Pattern Recognition, pp. 2122-2128, 2008.
[6] Salehi, N.B.;Kasaei, S.; and Alizadeh,S.;"Face Recognition Using Boosted Regularized Linear Discriminant Analysis," Computer Modeling and Simulation, ICCMS 2010, Vol.2,pp.89-93,2010.
[7] Hong Chang, Dit-Yan Yeong, Robust path-based spectral clustering. Pattern Recognition, Vol. 41, No. 1, pp. 91-203, 2008.
[8] Zhu M L, Martinez A M, Subclass discriminant analysis [J], *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 28, pp. 1274-1286, 2006.
[9] Tsang I W, Kocsor A, Kwok JT. Simpler core vector machines with enclosing balls[C]//Proceedings of the 24th International Conference on Machine Learning, Corvallis, Oregon, USA, pp. 911-918, 2007.
[10] Martinez A M, Zhu M L, Where are linear feature extraction methods applicable? [J]. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 27, No. 12, pp. 1934-1944, 2007.