Facial Expression Recognition Using Image Processing Techniques and Neural Networks

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Abstract. In our daily life, the facial expression contains important information responded to interaction to other people. Human Facial Expression Recognition has been researched in the past years. Thus, this study adds facial muscle streak, for example nasal labial folds and front lines, as another recognition condition.

We used the traditional face detection to extract face area from original image. Then to extract eyes, mouth and eyebrow outlines' position from face area. Afterward, we extracted important contours from different feature areas. Ultimately, we used these features to create a set of feature vector. Then, these vectors were used to process with neural network and to determine user's facial expression.

In summary, this study used TFEID (Taiwanese Facial Expression Image Database) database to determine the expression recognition and face recognition. The experiment result shown, that 96.2% and 92.8% of TFEID database can be recognized in personalizing expression recognition experiment and full member expression recognition, respectively. In face recognition, 97.4% of TFEID sample were recognized.

Keywords: Facial expression recognition, Face detection, Feature extraction, Feature areas.

1 Introduction

Human face researches contain face detection, face recognition and facial expression recognition. There are many scholars and researchers working on these researches. In face detection, Yang, Kriegman and Ahuja [1] had developed single picture face detection method. This method can be divided into four categories: Knowledge-based [2], Feature-based [3], [4], Template-matching [5] and Appearance-based [6], as well as Viola Jones [6] using Rectangle Feature in Integral Image, AdaBoost feature classifier and cascade classifier to find object or human face in pictures quickly.

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However, it is more complex in feature extraction. The detail face informations like feature position, size and muscle texture will be needed. Fasel and Luettin [7] had classified the feature extraction methods into two categories as deformation extraction[8], [9]and motion extraction [10]. On the other hand, Contreras had proposed the most important information of human face is contour of features [11]. He applied the edge detectors of Sobel and Canny to achieve completely contour of facial features. Majumder, Behera and Subramanian used the distant of facial features to detect the center of eye and the lip position effectively [9]. Similarly, Bashyal and Venayagamoorthy [12] using applied the Gabor filter in different angles to measure vector value of facial features and locate its position.

In this study, a new approach to including of image preprocessing, face detection, feature extraction, and classification is proposed and in attempting to achieve a more real timed characterization of facial images.

2 The Proposed System

Fig.1 illustrates process of the proposed approach, which includes image preprocessing, face detection, feature extraction and classification. Details of these processes are described in the following subsections.

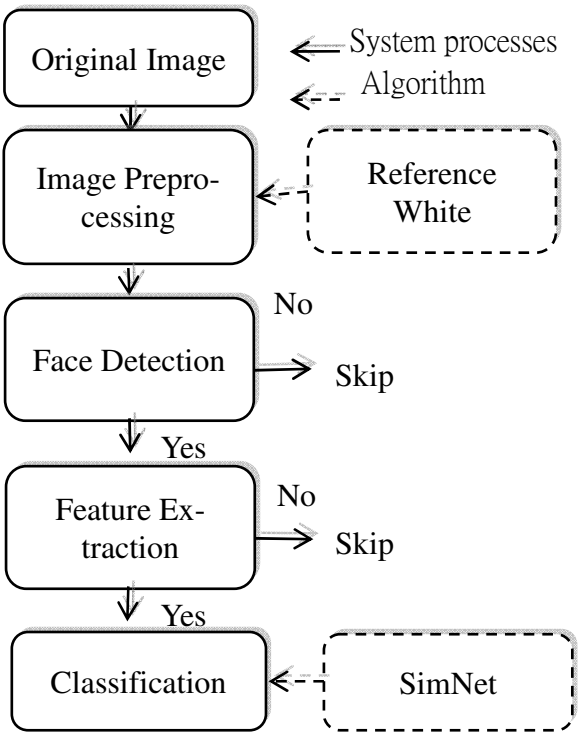


Fig. 1. Flow Diagram

2.1 Image Preprocessing

In image pre-processing, because the different environments, such as the different sources, will cause the final outcome. Our proposed system will adjust the light intensity of the facial expression to be recorded into the image pictures. Higher brightness of the pixel interval to calculated the mean in this image, and used this average value as the reference and calculation in equation (1).

$$\begin{cases} R_{avg} = \frac{\sum_1^n \max(N_R)}{n} \\ G_{avg} = \frac{\sum_1^n \max(N_G)}{n} \\ B_{avg} = \frac{\sum_1^n \max(N_B)}{n} \end{cases} \quad (1)$$

$$\begin{cases} R' = \frac{255}{R_{avg}} * N_R \\ G' = \frac{255}{G_{avg}} * N_G \\ B' = \frac{255}{B_{avg}} * N_B \end{cases} \quad (2)$$

The original image pixel adjustments based on average values. Where N_R, N_G and N_B represent the original image pixel values. R, G and B represent average value of a pixel in the color channel interval of n. n represent the total number of pixels to retrieve a brightness range, and R', G' and B' represent pixel values after the adjustment. This image pre-processing will be used to adjust for the low light images.

2.2 Face Detection

Viola and Jones [6] proposed real-time object detection algorithms to detect expression recognition of human face detection. This method compared with the color detection of face detection that can be excluded from the light source to the formation of the pixel values change in the error detection. During the experiment, the image of a miscarriage of justice will be skipped. Image pre-processing and face detection algorithm is illustrated in the flow chart shown in Fig 2.

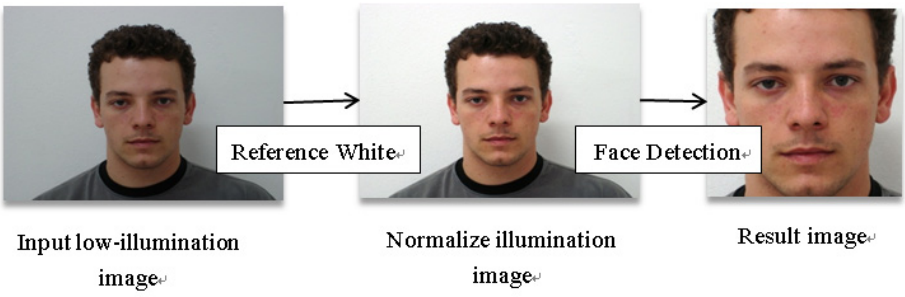


Fig. 2. Image pre-processing and face detection flowchart

2.3 Feature Extraction

In our proposed method, lots of features will be extracted from human face. We extracted eyebrows, eyes, and mouth all of region. Because the facial features location have relative distance relationship. The eyes will be detected at the first search region from face, and then identify the candidate position of the eyebrows, nostrils and mouth. Fig. 3 showed the feature extraction algorithm of the ROI-based Detection block. In our method, we extract 20 feature points and calculated the distance between points, then using the SimNet classification method to characterize the facial expression recognition.

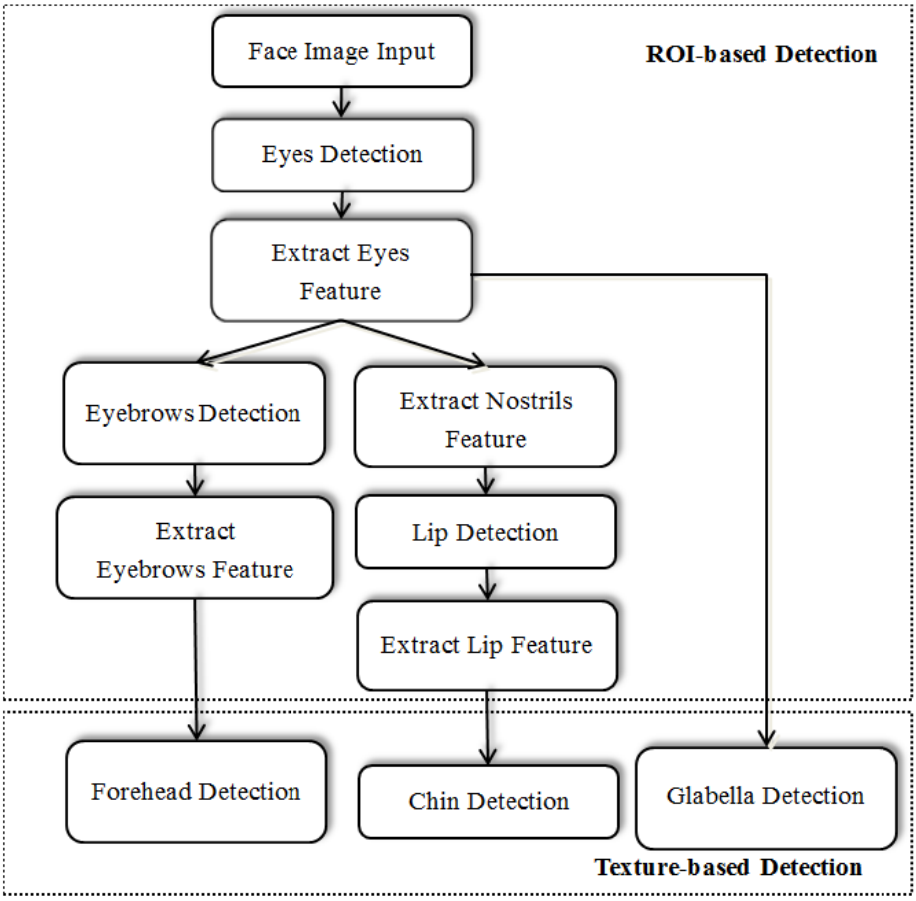


Fig. 3. Flowchart of feature extraction algorithm

- **Eyes Detection**

  It is clearly, eyes will physically change with a specific mode in any expression. For examples, the eyes will enlarge in surprised expression and shrink in disgust expression. In this step, we use the method proposed by Viola and Jones to detect the

candidate area surrounding eye in the face image. Then converted to YCbCr space to capture the Cr color channel and the binary image can be captured for determination of the eye contour. Then used as the connected components (see fig. 4).

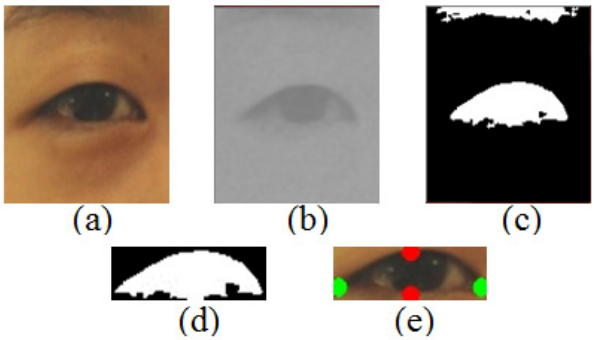


Fig. 4. (a) Original image (b) Capture Cr color channel(c) Binarization (d) Connected Component (e) Feature points location

- **Eyebrows Detection**

  It is recognized, the above eyes region is the important candidate region of eyebrows. The highest point of the eye feature point coordinates can retrieve the candidate region of the eyebrows. Then eyebrows candidate region converted to grayscale image from the RGB color space image and use Sobel horizontal directional edge detection to find the eyebrows region. In order to preserve the integrity of the eyebrow contour, and use Sobel edge detection will have excessive noise. Therefore, morphological filter to remove noise and then use the connected components and Canny edge detection to capture feature point (see fig. 5).

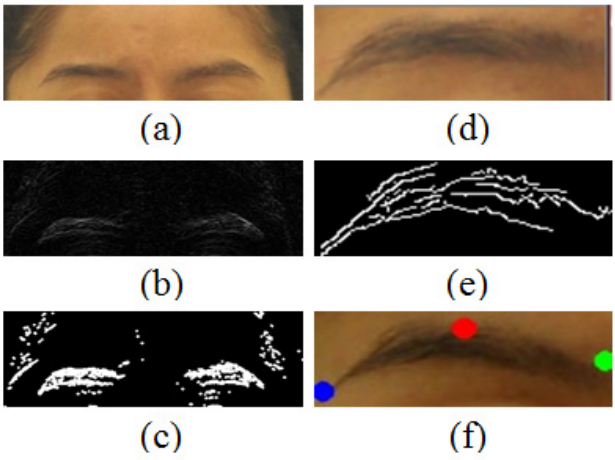


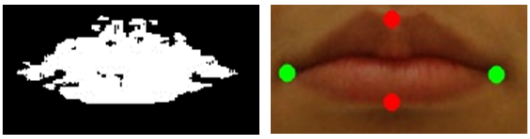
Fig. 5. (a) Eyebrows candidate region (b) Sobel edge detection (c) morphological filtering noise (d) connected components capture feature location of the eyebrow area (e) Canny edge detection (f) feature points

- **Lip Detection**

  Anima Majumder [9] proposed method of mouth detection uses a simple fundamental of facial geometry. From the facial geometry, we can easily observe the approximate width of the lip is same as the distance between two eyes centers. Then use color threshold to detection lip region. By using Chora's [13] proposed method of lip contour uses color detection. The color space was first converted to HSV and then separated into the three color channels. The proposed threshold for detection lips was illustrated in equation (3).

$$\begin{cases} H > 334 \cup H \leq 10 \\ S \leq 25 \end{cases} \tag{3}$$

  The sample results of lips detection algorithm are presented in fig. 6.



(a) (b)

Fig. 6. (a)The detection of HSV lip images (b) Lips feature location

- **Texture Based Detection**

  In facial expression recognition, in addition to the characteristics of the facial position changes those different expressions of the facial muscles to form different texture, the forehead, and brow and chin area are important for significantly detail changes. We based on the results of feature point extraction to capture the three regions of the forehead, brow and chin (as show in fig. 7). This experiment uses the mask of Sobel edge detection to detect the edge of the skin characteristics.

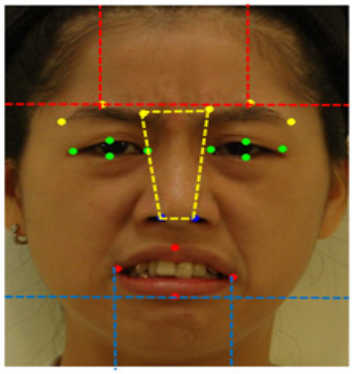


Fig. 7. Texture detection schematic

- **Features Normalization**

  Because of the different scales of faces in picture (even the same person), we have to normalize the features. We used the distance between each feature point (as see in fig. 8). At first, we create a personal expression of model and using equation (4).

$$ND_i^{Neutral} = \frac{1}{n}\sum_{j=1}^{n} ND_{i,j}^{Neutral_m} \quad (4)$$

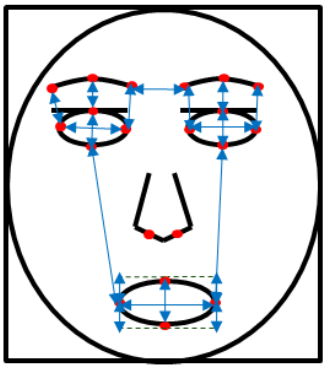


Fig. 8. The distance between feature points

3 Expression Recognition Using SimNet

SimNet is Fuzzy Logic combined with Artificial Neural Network. They have Unsupervised Learning and Supervised Learning. We use the SimNet with two hidden layers and each layer contains twenty neurons. Our proposed system will fed the hidden layer with the twenty normalize features. The output layer outputs eight values and each value represents one kind of expression. The highest value of each image will be indicated to the corresponding facial expression. The network architecture is shown as fig. 9.

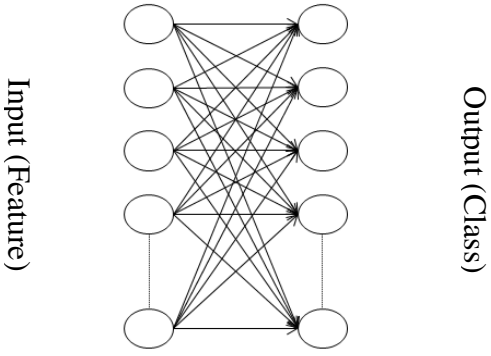


Fig. 9. Proposed network architecture

4 Experiment Results

We used the Taiwanese Facial Expression Image Database (TFEID) [14] to conduct our experiments. In this study, the original image to the right and left offset of 1° to 2°. There are having 960 of images. Then we used two kinds of experiment on database. TABLE 1 show personalized facial expression recognition system and TABLE 2 show all members of the facial expression recognition system.

Table 1. Personalized facial expression recognition system result

Database	People	Training images	Testing images	Accuracy (%)
TFEID (Woman)	15	320	235	92.9%
TFEID (Man)	9	169	128	99.4%
TFEID (Total)	24	489	363	96.2%

Table 2. All members of the facial expression recognition system result

		Recognition expression								Accuracy (%)
		Ang	Con	Dis	Fea	Hap	Neu	Sad	Sur	
Actual expression.	Anger	39	2	2	2	0	0	2	0	83.0%
	Contempt	0	43	0	1	0	1	0	0	95.6%
	Disgust	1	1	44	0	0	0	0	1	93.6%
	Fear	0	0	0	43	0	0	0	0	100.0%
	Happiness	0	0	0	3	47	0	0	0	94.0%
	Neurosis	2	0	0	0	0	48	0	0	96.0%
	Sadness	3	1	0	1	0	2	42	1	84.0%
	Surprise	0	0	0	0	0	0	0	31	100.0%
Average										92.8%

Table 3. All members of the personalized facial expression recognition system result

		Recognition expression							Accuracy (%)
		Ang	Con	Dis	Fea	Hap	Sad	Sur	
Actual expression.	Anger	40	0	0	0	0	7	0	85.1%
	Contempt	1	41	0	0	1	2	0	91.1%
	Disgust	2	2	41	2	0	0	0	87.2%
	Fear	1	0	4	35	0	2	1	81.4%
	Happiness	0	0	0	1	48	0	0	96.0%
	Sadness	3	3	3	2	2	36	1	72.0%
	Surprise	0	1	0	0	1	0	29	93.5%
Average									86.3%

5 Conclusions

We presented a system to automatically recognize the facial expressions. Our system extracted and described the features from the contour of eyebrows, eyes and mouth by a scalable rectangle. This is an improvement over the ways for using manual facial characteristic points and complicated face mask model. We defined less features to reduce the recognition time and obtain appropriate recognition accuracy.

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