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Research on facial expression recognition based on LVQ neural network

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Abstract: This paper presents a facial expression recognition method based on LVQ neural network combined with Local Binary Pattern and principal component analysis. Through the face part of the face detection to extract the image and the image preprocessing, using Local Binary Pattern and principal component analysis method to achieve the image data dimension reduction, the facial expression characteristic matrix, structure for facial expression recognition based on LVQ neural network model, and in Cohn - Kanade facial expression library experiment, using the model of this paper to identify surprised, angry, happiness and disgust expression, finally get the average recognition rate of over 80%, verify the feasibility of the model for facial expression recognition. In addition, the recognition rate of facial expression feature matrix after adding principal component analysis is compared, and a conclusion is drawn that the Local Binary Pattern combined with principal component analysis can improve the recognition rate.
Keywords: Facial expression recognition, LVQ neural network, LBP, PCA.

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1. INTRODUCTION

With the development of society and the advancement of science and technology, people's demand for the safety and concealment of personal information is also increasing, and the corresponding identification technology is also developing rapidly. Existing technology can realize many kinds of identification authentication, among which face recognition stands out because of its uniqueness, uniqueness, and direct and friendly characteristics. In recent years, facial expression recognition has been a hot topic in the field of face recognition. Facial expression recognition is widely used in computer vision, criminal investigation, social sentiment analysis, medical treatment, fatigue detection, lie detection, etc. [1].

Facial expression recognition mainly includes three steps: facial image detection, expression feature extraction and expression classification. Among them, the methods of face image detection can be divided into three types, knowledge-based methods, statistical model-based methods, and template matching-based methods [2].

Facial expression feature extraction is the most critical step in facial expression recognition, that is, to extract the key features that can express the expression in facial expressions. At present, the main facial expression feature extraction includes geometric features, texture features and fusion features [3]. The geometric feature is mainly to extract the facial feature points of the face, including the eyes,

mouth and other parts, and use the geometric relationship of the feature points to express the facial features. The main geometric feature extraction algorithms are based on Active Shape Model (ASM) and Active Appearance Model (AAM)[4].

Texture features can express changes in different parts of a human face. For example, when a person is happy, the corners of his mouth will rise, and when a person is surprised, they will open their eyes. Common texture feature algorithms mainly include wavelet transform and Local Binary Pattern (LBP).

The methods used in facial expression classification are mainly machine learning methods, such as support vector machines, dynamic Bayesian networks, etc. Recently, the more popular deep learning also shows strong performance in the field of pattern recognition, but deep learning requires a large amount of data to train the network and requires very powerful hardware support.

Through the research on facial expression recognition, most of the classifiers are support vector machines [5]. LVQ neural network is rarely used for facial expression recognition. Because of its simple network structure, LVQ only uses the interaction of neurons in the structure. It can complete complex classification processing, and it is easy to converge various complicated and scattered design conditions in the design domain to the conclusion. This article attempts to use LVQ neural network to recognize facial expressions, and proposes a method based on LVQ neural network combined with local binary pattern and principal component analysis to realize facial expression recognition.

2. LOCAL BINARY PATTERN

Local Binary Pattern, which can express the texture information of the image very well, has the advantage of gray invariance, and has achieved good results after being applied to the field of face recognition. LBP uses a 3*3 scan window, takes the pixel value of the pixel in the middle of the scan window as the threshold, and encodes the eight pixel values around it, and selects the pixel value clockwise from the upper left corner of the scan window, and compares it with the threshold For comparison, if the pixel value is less than the threshold, it is recorded as 0, and if the pixel value is greater than the threshold, it is recorded as 1. In this way, an 8-bit binary number (256 types in total) can be obtained, which reflects the texture information of the window [6]. The calculation process is shown in Figure 1. Comparing clockwise from the starting point with the threshold, the 8-bit binary number obtained is 00010011, which is the LBP code value of the sampling window. The code value has a total of eight bits. The eight-bit LBP operator corresponds to the pixel value of the center pixel (LBP operator The range is exactly between 0~255 after converted to decimal).

The calculation formula of LBP is:

$$LBP(X_C, Y_C) = \sum_{P=0}^{P-1} 2^P S(i_p - i_c) \tag{1}$$

Among them, (X_C, Y_C) represents the coordinates of the central pixel, i_p represents the pixel value of the surrounding pixels, and i_c represents the central threshold. p represents the number of pixels in the window, and $S(x)$ is a symbolic function, defined as:

$$S(x) = \begin{cases} 1 & , x \geq 0 \\ 0 & , x < 0 \end{cases} \tag{2}$$

Fig. 1 LBP calculation process

3. PRINCIPAL COMPONENT ANALYSIS

PCA is a common data analysis method [7-8]. When facing high-dimensional data, too many variables will increase the complexity of calculation. Principal component analysis transforms high-dimensional data into low-dimensional linear Irrelevant means to extract the main feature components of the data. These feature components keep the original information as much as possible, and achieve the effect of high efficiency and dimensionality reduction while reducing the amount of calculation. It uses an orthogonal transformation to transform the original random vector whose components are related to a new random vector whose components are not related, and make it point to the p orthogonal directions where the sample points are most spread, and then reduce the dimensionality of the multidimensional variable system Processing, so that it can be converted into a low-dimensional variable system with a higher precision. The basic steps of the PCA algorithm are:

With M samples: $X^{(1)}, X^{(2)}, X^{(3)}, \cdots, X^{(M)}$, ,Each sample has N features: $X^{(M)} = (X_1^M, X_2^M, X_3^M, \cdots, X_N^M,)^T$。

Calculate the mean vector of the sample feature vector:

$$\overline{X}^{(M)} = \frac{1}{N}\sum_{i=1}^{N}\overline{X}_i^{(M)} \tag{3}$$

Calculate the scatter matrix S:

$$S = \sum_{i=1}^{N}(X_i^{(M)} - \overline{X}^{(M)})(X_i^{(M)} - \overline{X}^{(M)})^T \tag{4}$$

Use the singular value decomposition theorem to calculate the eigenvalues λ and eigenvectors of the scatter matrix W_{PCA}.

Sort by the size of eigenvalues.

The feature vector $W_{PCA1}, W_{PCA2}, \cdots, W_{PCAN}$ corresponding to the first K largest feature values λ_1, $\lambda_2, \cdots$, λ_K is used as the final feature vector for identification.

4. LEARNING VECTOR QUANTIZATION

LVQ neural network [9] is composed of input layer, competition layer and linear output layer. The input layer and the competition layer are fully connected, and the competition layer and the linear output layer are partially connected. When a certain input mode is introduced into the network, the nearest competitive layer neuron is activated, and the neuron state is "1". The neuron state of other competing layers is "0". The state of the linear output layer neuron connected to the activated neuron is also "1", and the state of the other output layer neurons is "0".

5. FACIAL EXPRESSION RECOGNITION

Facial expression recognition is divided into three steps, as shown in Figure 2

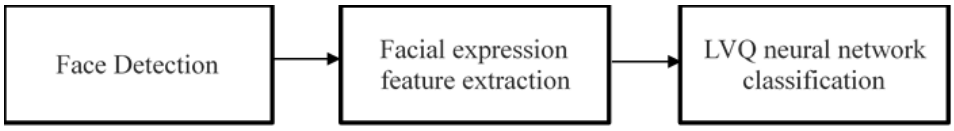

Fig.2 Facial expression recognition procedures

This study used the Cohn-Kanada database and selected 300 pictures of angry, happy, disgusted, and surprised expressions as the test. Including 79 angry expression pictures, 72 sad expression pictures, 78 surprised expression pictures, and 71 disgust expression pictures.

5.1 Face Detection

First, the face is detected, and the part of the face is extracted. The face classifier trained by opencv is used to detect the face of the picture. After that, the obtained face image needs to be preprocessed. The importance is second only to feature extraction. If this stage is not handled well, the subsequent work will affect the recognition rate of the network. In practical applications, preprocessing has two main functions. On the one hand, the image quality is not high due to noise, illumination, etc., so preprocessing is required. On the other hand, the acquired image does not meet the specific requirements of subsequent operations, so preprocessing is also required.

For noise processing, the median filter [10] is used. The median filter compares the gray values of the center pixel with the surrounding pixels, and the pixels with larger gray values are close to the surrounding pixels, thereby eliminating isolated Noise points.

For database pictures taken under different lighting conditions, using histogram equalization [11], the histogram equalization processing is to change the grayscale histogram of the original image from a relatively concentrated grayscale interval to all grayscale Uniform distribution within the range, histogram equalization is to stretch the image non-linearly, and redistribute the image pixel values so that the number of pixels in a certain gray scale range is roughly the same. Histogram equalization is an important application of gray scale transformation and is widely used in image enhancement processing.

Before feature extraction, the primary task for face detection is to segment the face image and locate the main organs, and normalize the face image. By scaling the image according to the scaling factor, a calibration image with a uniform size is obtained. Finally, the processed image is scaled to 64*64.

5.2 Facial expression feature extraction

In this paper, the LBP texture feature extraction is performed on the mouth features with high expression contribution rate [12]. Some expressions such as disgusted and angry mouth features are very similar. The processing method is to extract the entire face image with similar expressions to improve the recognition rate. The facial expression feature extraction process is as follows: segment the detected image of the face, the lower half is the image of the mouth, and then use the LBP algorithm to scan the image of the mouth, and divide the detection window into 16*16 small areas. Get the histogram of each small area, and connect the information corresponding to the obtained histogram into a feature vector, and so on, get the vector corresponding to the histogram of each picture, integrate the obtained vectors, and finally Get the vector integration matrix of all pictures.

Principal component analysis (PCA) is used to reduce the dimensionality of the obtained feature matrix, the principal components are extracted through linear combination, and the original variable

feature information is concentrated and integrated, so that it is easier to grasp the features and improve the analysis efficiency. We select the first 15 principal components with a cumulative contribution rate of 90%, and reduce the original feature matrix from 256 dimensions to a 15-dimensional matrix to obtain the facial expression feature matrix.

5.3 LVQ neural network classification

After getting the facial expression feature matrix. For the sake of generality, 250 sets of data are randomly selected as the training set, and the remaining 50 sets of data are used as the test set. The number of input neurons is 15, and the number of columns of the facial expression feature matrix is obtained after principal component analysis. The number of output neurons is 4, which respectively represent four expressions of surprise, disgust, happiness, and anger.

Use newlvq() provided by MATLAB to create an LVQ network, set the number of neurons in the competition layer to 23, and the learning rate to 0.02.

The network is trained 10 times, and the recognition rate of happy, disgusted, angry, and surprised expressions after each training is obtained, and the average recognition rate of the 4 expressions is taken.

This paper separately trains the feature matrix without principal component analysis and the feature matrix after principal component analysis. The comparison results of training are shown in Table 1:

Table.1 Result of contrast

Serial number	emtion	Whether it is processed by PCA	Average recognition rate
1	surprise	After PCA treatment	82.1125
2	disgust		98.4125
3	happiness		80.9
4	anger		87.275
1	surprise	Before PCA treatment	82.5
2	disgust		95.625
3	happiness		79.875
4	anger		55.82

6. CONCLUSION

It can be seen from the results that the average recognition rate after model training is above 80%, and the application of LVQ neural network to facial expression recognition is feasible. Through comparison, it can be seen that the recognition effect after fusion of LBP features and principal component analysis is more significant. The LVQ neural network method that combines LBP and principal component analysis proposed in this paper is feasible for facial expression recognition.

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