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A novel fusion method of PCA and LDP for facial expression feature extraction

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ABSTRACT

Facial expression recognition is a research hotspot in the field of human–computer interaction in recent years. The existing method of fusing PCA and LBP for feature extraction is susceptible to random noise and the change of non-monotone illumination. This paper proposes a new fusion method of PCA and LDP (Local Directional Pattern) for feature extraction. First, PCA is adopted to extract global features of facial images. Then LDP operator is used to extract local texture features of eyes and mouth area. After combining the global features with local texture features, the fusion features are obtained. Finally, support vector machine (SVM) is applied to classify and recognize facial expression. The experimental result shows that the method proposed in this paper is more effective than solely adopting PCA or fusion of PCA and LBP. It's more robust to noise and change of non-monotone illumination, and improves the rate of facial expression recognition.

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1. Introduction

Facial expression recognition is an important part in research of computer vision and human–computer interaction. The methods of facial expression feature extraction were divided into two types, global feature extraction and local texture feature extraction. The global feature extraction mainly considered the change of facial morphology, which was caused by the movement of facial muscles. The classic algorithms of the global feature extraction included independent component analysis (ICA) [1], principal component analysis (PCA) [2] and discrete cosine transform (DCT) [3], and etc. However, researchers found that it was difficult to obtain complete information of facial expression features when solely using global feature extraction, which would lead to low recognition rate. Therefore, researchers at home and abroad combined global features with local texture features to obtain fusion features. Among them, Luo etc. [4] proposed a method which combining PCA with LBP to obtain fusion expression features. The experimental result showed that the recognition of fusion features was higher than single features and other fusion features. But the texture features extracted by LBP was susceptible to random noise and the change of non-monotone illumination, which were not conducive to the subsequent classification and recognition.

This paper proposes a novel fusion method of PCA and LDP for facial expression feature extraction, which combines global features extracted by PCA with local texture features extracted by LDP. This method can not only make up the insufficiency of the information in characterization of facial expressions, but also overcome the influence of random noise and the change of non-monotone illumination well.

2. Fusion of PCA and LBP

2.1. PCA

Principal component analysis is a method that can reduce the dimension of image data and simplify the data structure. The essence of PCA is mapping the data of high-dimensional space into low-dimensional space through orthogonal transformation, and thus, the main features of facial images can be extracted [5].

2.2. PCA and LBP

LBP is an effective texture description operator. It can extract the local neighbor texture information of grayscale image [6].

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Literature [4] used PCA to extract the global features of facial image and obtain the global feature vector. And then LBP operator was adopted to extract texture features from the mouth area, where there will be greater contribution to facial expression recognition than other areas, the process was as follows. First, the preprocessed image of face area was segmented. Then LBP operator was adopted to scan the mouth area to obtain coding image. Finally, it extracted the LBP histogram of mouth area. Then combining global features extracted by PCA with texture features extracted by LBP to obtain the fusion features. Lastly, SVM was applied to classify the fusion features and recognize different expressions. The experimental result showed that the recognition of fusion features was higher than single features and other fusion features. But the texture features extracted by LBP was susceptible to random noise and the change of non-monotone illumination, which were not conducive to the subsequent classification and recognition.

3. Fusion of PCA and LDP for feature extraction

3.1. LDP

Local directional pattern (LDP) was proposed by Jabid in 2010 [7]. It was an improved method for texture feature extraction. LDP inherited the advantages of the texture feature which was extracted by LBP, and also had a good stability for random noise. LDP is an eight-bit binary code assigned to each pixel of an input image. This pattern is calculated by comparing the relative edge response value of a pixel in different directions. Therefore, this paper calculates eight directional edge response value of a particular pixel by using Kirsch masks in eight different orientations. These masks are shown in Fig. 1.

The returned values of eight directional are obtained by convolution operation with the eight kirsch masks $M_0, M_1, \ldots, M_7$. And the eight edge response values $m_0, m_1, \ldots, m_7$ are obtained, which are shown in Fig. 2.

For the convenience of coding, this paper takes the absolute value of the eight edge response values. As the response values are not equally important in all directions, the presence of corner or edge show high response values in particular direction. So we set values of the top k to 1, and set the other $(8-k)$ values to 0, let m_0 as the first of eight-bit binary. This paper references the LDP code value as follows [8]:

$$\begin{bmatrix}-3&-3&5\\-3&0&5\\-3&-3&5\end{bmatrix}\quad\begin{bmatrix}-3&5&5\\-3&0&5\\-3&-3&-3\end{bmatrix}\quad\begin{bmatrix}5&5&5\\-3&0&-3\\-3&-3&-3\end{bmatrix}\quad\begin{bmatrix}5&5&-3\\5&0&-3\\-3&-3&-3\end{bmatrix}$$

M_0 M_1 M_2 M_3

$$\begin{bmatrix}5&-3&-3\\5&0&-3\\5&-3&-3\end{bmatrix}\quad\begin{bmatrix}-3&-3&-3\\5&0&-3\\5&5&-3\end{bmatrix}\quad\begin{bmatrix}-3&-3&-3\\-3&0&-3\\5&5&5\end{bmatrix}\quad\begin{bmatrix}-3&-3&-3\\-3&0&5\\-3&5&5\end{bmatrix}$$

M_4 M_5 M_6 M_7

Fig. 1. Kirsch masks.

m_3	m_2	m_1
m_4	X	m_0
m_5	m_6	m_7

Fig. 2. The returned values of eight directional.

$$\mathrm{LDP}_k = \sum_{i=0}^{7} S_i(m_i - m_k)2^i \quad (1)$$

here, $s(x) = \begin{cases} 1, & x \geq 0 \\ 0, & x < 0 \end{cases}$, m_k is the kth largest edge response value, here $k=3$, then calculates the corresponding LDP histogram as the following formula:

$$H_{\mathrm{LDP}_i} = \sum_{x,y} f(\mathrm{LDP}_k(x,y), c_i) \quad (2)$$

here, $f(a, c_i) = \begin{cases} 1, & a = c_i \\ 0, & \text{others} \end{cases}$, c_i is the LDP code value. The process of encoding one pixel of the image by using LDP operator is shown in Fig. 3.

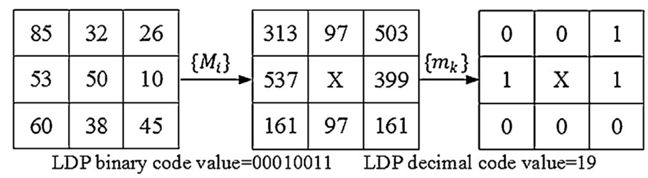

Fig. 3. Encoding process of LDP ($k=3$).

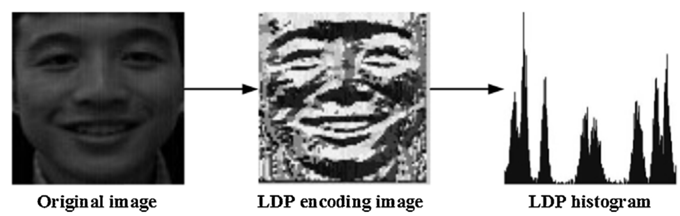

Fig. 4. LDP features extraction.

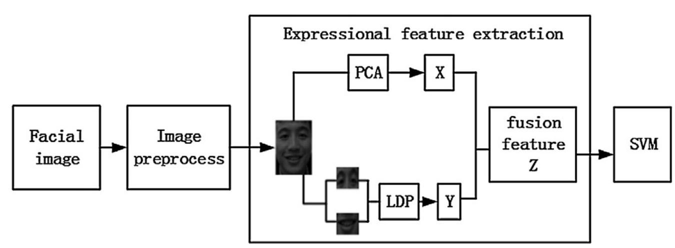

Fig. 5. The process of feature extraction and expression recognition.

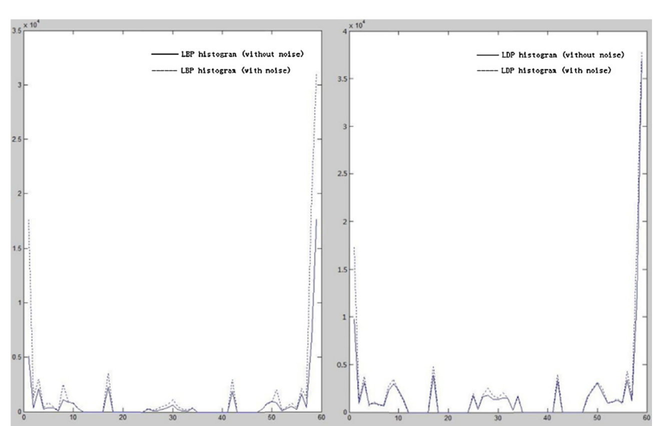

Fig. 6. The contrast of LBP and LDP histogram with or without gauss noise.

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