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Study of Emotion Recognition Based on Electrocardiogram and RBF neural network

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Abstract

This paper compares the emotional pattern recognition method between standard BP neural network classifier and RBF neural network classifier. The experiment introduces wavelet transform to analyze the Electrocardiogram (ECG) signal, and extracts maximum and standard deviation of the wavelet coefficients in every level. Then we construct the coefficients as eigenvectors and input them into BP and RBF neural network, then take a comparison of their experimental results. The result of experiment also show that the wavelet coefficients as the eigenvector can be effective characterization of ECG. The classification of the samples with BP neural network gets overall recognition rate of 87.5%, but RBF gets overall recognition rate of 91.67%. So compared with BP neural network, RBF has a better recognition rate for emotional pattern recognition.

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Keywords: Electrocardiogram (ECG)； Physiological Signal; Emotion Recognition; Wavelet Transform(WT); RBF neural network

1. Introduction

For emotion recognition, previous methods have been used and a variety of recognition results have achieved [1]. This paper focuses on the radial basis function (RBF) neural network classification

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algorithm for emotion recognition method. Electrocardiogram (ECG) with a single cardiac cycle is transient and non-stationary signal. So we introduce wavelet decomposition method for analysis of ECG signal, extract more effective and reliable signal characteristics. ECG signal is decomposed at six levels. We extract the maximum value of multi-scale wavelet coefficients and standard deviation, then construct a 14-dimensional feature vector, and input them to RBF neural network classifier for emotion recognition.

Experiment results show that the method can detect and identify four emotional signals (joy, anger, sadness and pleasure) on the surface EMG successfully, providing a more effective experimental method for the detection of emotional model.

2. Material and methods

2.1. RBF Neural Network Algorithm

RBF neural network is a feed forward neural network with three layers, as shows as Fig.1. It consists of the input layer, hidden layer and the output layer. The most important characteristics of RBF network are hidden layer neurons in the middle of the basis function only have local reactions of input function. That is, the basic function can produce a significant nonzero response when the input space only falls on a local area. In other cases, the output of basis functions is small [2].

When we use the radial basis function neural networks, pattern classes can be thought as the midpoint in the model space of the Gaussian distribution. Therefore, the classification performance of RBF neural network depends on the hidden layer produced by u-dimensional nonlinear transformation which has the character of spatial separability of each cluster largely. The Gaussian width and the distance are also important in the process of pattern classification [3]. As shows in Fig.2, arrows point is much closer to the center of k classes. But by the choice of the Gaussian width the vector points can be made to k classes. This is the reason why the performance of RBF neural network classification is superior then nearest neighbor classifier exactly.

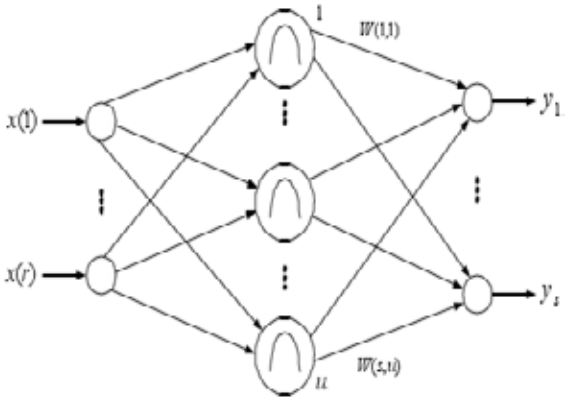

Fig.1 RBF Network

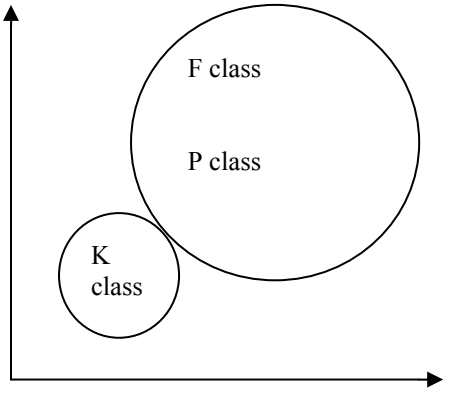

Fig.2 The role of the Gaussian width

3. Wavelet Analysis

Wavelet transform is a local transformation of time and frequency, which can effectively extract information from the signal through computing functions such as dilation and translation functions or

multi-scale refinement of signals (Ultiscale Analysis). It can solve many difficult problems which Fourier transform can not be solved [4].

The meaning of Wavelet transform is to transform a basic wavelet or mother wavelet as function $\psi(t)$ to do the displacement b, then do with the inner product of the analyzed signal $f(t)$ under a different scale a to. The wavelet transform of a given energy limited signal shows as follows [5].

$$W_f(a,b)=[f(t),\psi_{a,b}(t)]=a^{-1/2}\int_{-\infty}^{+\infty} f(t)\psi(\frac{t-b}{a})dt \qquad (1)$$

Where, a is scale parameter and b is the translation parameters.

In order to facilitate computer processing of ECG signal in wavelet analysis, we should discrete scale factor a and translation factor b (often taking a = 2j and b = 2j k, j, k ∈ Z). The signal time is expressed as f (n) (n ∈ Z) usually. Mother wavelet and the corresponding wavelet should be discrete, expressed as Ψ (n) and Ψjk respectively. Therefore, the wavelet transform of discrete dyadic shows as follows:

$$DWT_\psi f(2^j,2^j k)=\sum_{n=-\infty}^{+\infty} f(n)\psi_{j,k}(n)=2^{-j/2}\sum_{-\infty}^{+\infty} f(n)\psi(2^{-j}n-k) \qquad (2)$$

This paper uses compactly supported orthogonal Db5 wavelet bases which have following properties. The time domain has limited support, that is, $\psi(t)$ has a limit length. In frequency domain, $\psi(m)$ has zero at5 order when $\omega_0=0$. What's more, $\psi(t)$ and its integer motion has orthogonal characterist, that is $\int\psi(t)\psi(t-k)dt=\delta_k$. It has regular good regularity in the performance of wavelet differentiability. It is not only the smoothness description of the function, but also the function in frequency domain measure of the energy.

The choice of best layers of wavelet decomposition is difficult to determine. After a six layers ECG wavelet decomposed, we can get fuzzy components and detail components. Then we select the detail components as the feature vector of which the waveform components are well preserved to finish the process of reconstruction. Because the standard deviation and the maximum can describe the waveform more completely, so this paper use the standard deviation and the maximum of detail component layers to build a feature vector [6, 7] for emotion pattern recognition.

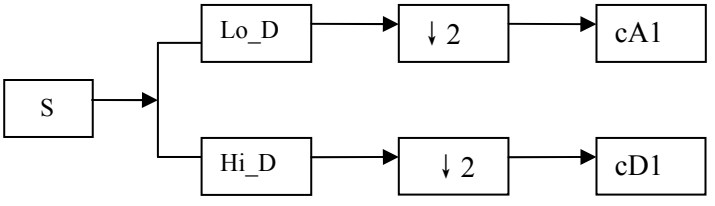

Fig.3 The process of wavelet decomposition

4. Emotion Recognition Experiment Process and Result

Experiment was carried out in the MATLAB 2008 environment. The physiological signal data of ECG is from the Augsburg University in Germany, it is four kinds of emotions, joy, anger, sadness and pleasure, generated by a subject's conduct of music by Johannes Wagner and others through the selective emotional music, with a total of Record a 25-day ECG physiological signals[8].

In this paper, we decompose four emotional ECG (joy, anger, sadness, pleasure) in six layers. Then we extract standard deviation and maximum wavelet coefficients of each layer, and form a characteristic vector with 14 dimensions. Table I shows the maximum and standard deviation of six-scale wavelet decomposition in the five emotional joy experiments, respectively (just take the first 6 days). Then the maximum and the standard deviation will constitute a 14-dimensional feature vector as the feature vectors of the surface EMG. Then we input the vectors into the BP neural network and RBF neural network and compare the results.

Table I the maximum of typical joy of surface EMG signal

	joy						
	a6	d6	d5	d4	d3	d2	d1
1	3647	1494	2678	3654	2529	1671	252.5
2	2098	1642	2769	3691	2535	1484	233
3	1093	1299	2606	3539	2538	1518	226.3
4	1840	1317	2143	3060	2247	1374	210.7
5	2055	1586	2377	3143	2233	1426	208.3
6	1517	1242	2292	2815	2019	1133	165.9

In this paper, experiment consists by following steps. The first step, emotion feature vectors data in 19 days of 25 days is selected as the training set. Total samples of 4 training emotional types will be 100 groups. In the program each sample of the training set corresponds to the each value model. The second step, the other 6 days emotion feature vectors data will be the test set, a total of 24 sets of data. The third step, we train the network to get the statistical results. The physical meaning of parameters is equivalent to the grid structure, serves as testing and the input of identifying of new samples. The fourth step, its output parameter is the training results of statistics. It displays '1' with correct identification and '0' with error identification.

The train function of the network shows as: net = newrbe(P,T,spread); net = newrb (P,T,goal,spread,MN,DF); net = newgrnn (P,T,spread);

Final results of the experiment show as follows:

Result = ~sum(abs(X-x2))

Percent = sum(Result)/length(Result)

Experiments show that the overall recognition of RBF neural network to classify the test samples is 91.67%. It can be seen on the training process that the RBF neural network has a simple structure, nonlinear approximation ability, fast convergence and global convergence of significant advantages.

5. Results and conclusion

Physiological signal selected in this paper is ECG. We use RBF neural network as a pattern classifier. This paper uses the feature vectors of ECG signal by multi-scale wavelet decomposition to extract the

maximum value of wavelet coefficients and standard deviation. Then we put them into RBF neural network classifier for emotion recognition, experimental results show that it has a good pattern recognition rate. With full text of the discussion and testing, and comparison with other recognition algorithms, we can draw some useful conclusions:

1. RBF neural network has a simple structure, nonlinear approximation ability, fast convergence and global convergence of significant advantages. RBF neural network classifiers can better identify four emotional ECG signal with joy, anger, sadness, pleasure, it has a higher recognition rate and better robustness. Experimental results show that the application of emotion recognition is feasible and effective based on ECG signal and wavelet transform feature extraction and classification with RBF as a tool for the identification method.

2. From the pattern recognition results, this paper also proves that two groups of feature vectors with maximum and standard deviation are able to better characterize of the different ECG signals.

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