Study on Analysis and Pattern Recognition of the Manifestation of the Pulse Detection of Cerebrovascular Disease

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Abstract. Cerebrovascular Disease (CVD) is also called stroke in Traditional Chinese Medicine (TCM). CVD is a kind of frequent diseases with high incidence, high death rate, high deformity rate and high relapse rate. The pathogenesis of CVD has relation to many factors. In modern medicine, we can make use of various instruments to check many biochemical parameters. However, at present, the early detection of CVD can mostly be done artificially by specialists. In TCM the salted expert can detect the state of a CVD patient by felling his (or her) pulse. It is significant to apply the modern information and engineering techniques to the early discovery of CVD. It is also a challenge to do this in fact. In this paper, the authors presented a detection method of CVD basing on analysis and pattern recognition of Manifestation of the Pulse of TCM using wavelet technology and Neural Networks. Pulse signals from normal health persons and CVD patients were studied comparatively. This research method is flexible to deal with other physiological signals.

1. Introduction
The reason of Cerebrovascular Disease (CVD) is quite complex, the pathogenesis of this disease has relations to many factors such as Hyperlipidemia, hypertension, arteriosclerosis and so on. A research on baseline TC level and the risk of CVD was done in 30384 subjects aged 35-64 years, performed from 1992 to 2002 in 11 provinces in China showed that the risk of CVD increases continuously with increasing TC level [1]. Other researchers studied the association between CVD and the platelet glycoprotein [2,3].

At present, besides magnetic resonance angiography that is relatively consummate in the diagnoses of intracranial thrombosis, the Color Doppler Ultrasonography can be also applied to diagnose acute arterioembolism and acute arteriothrombosis.

Obviously, magnetic resonance angiography and Color Doppler Ultrasonography is deficient in preventive examination. It is the main measure for detection of CVD to observe and analyze hemorheological parameters. By determining blood viscosity, plasma viscosity and hematocrit, all-around analysis can show the risk of CVD. However, hemorheology isn’t universal, effective, and unwounded because hemorheology is limited by instrument, condition, the requirement of special knowledge and the complexity of CVD.

Since CVD is the result of the human body holistically deteriorated, the change of hemorheological parameter is one embodiment of pathological changes. Manifestation of the Pulse of Traditional
Chinese medicine (TCM) has traditional predominance in grasping all-around pathological changes of patients [4]. In this paper, the authors combined modern signal processing and Pattern Recognition technology with the Manifestation of Pulse in TCM and tried to develop a pre-detection method of CVD. Study results showed that we could successfully extract the feature of the Manifestation of the Pulse of CVD patients.

2. The measurement of the Manifestation of the Human Pulse signal
The characterization of pulse information is that makes use of advanced instruments such as Electropulsograph, and applies scientific test technology and method to measure the pulse signal, and then make the quantitative analysis feature extraction and pattern recognition of pulse signal by computer. This paper made a contrast research on the pulse signals of normal healthy people and CVD patients on the basis of many kinds of normal pulse signals in the researches of other experts. (refer to figure 1).

The system consists of the signal sensing, amplifier and filter, A/D, computer, and relative software. The biosensor is contacted directly to patients’ body. It transforms the biosignal into the electric signal that will be as the input signal to the apparatus. The electric signal becomes digital signal after being amplified, filtered and transformed into digital signal by the analogue to digital converter (A/D), and then the signal is transferred to computer for analyzing and disposing. The computer real-time display the biosignals graph that have been gathered, and use wavelet analysis and Neural Network (NN) algorithm to extract the features and recognize the patterns of the signals. At last, the computer will give the diagnoses and judgements basing on the methods hereinafore.

3. The wavelet denoise of the Manifestation of the Human Pulse signal
There is noise in Manifestation of the Pulse gathered, so the signal makes against observation and research. This paper adopted Wavelet transform to denoise efficiently, and it also made for system stability.

The formulation in Wavelet Transform [5]:
To continuous signal, the definition of Wavelet Function:
\[ \psi_{a,\tau} = \frac{1}{\sqrt{a}} \psi \left( \frac{t - \tau}{a} \right) \]  
(1)

Thereinto: \( a \) is dilation factor; \( \tau \) is translation motion factor
The Definition of Continuous Wavelet transform (CWT) of signal \( x(t) \):
\[ CWT_x(\alpha, \tau) = \frac{1}{\sqrt{\alpha}} \int x(t) \psi^* \left( \frac{t - \tau}{\alpha} \right) d\tau \]  
(2)

Inversion(reconstruct signal):
\[ f(t) = \frac{1}{C_\psi} \int \frac{1}{\alpha^2} CWT(\alpha, \tau) \psi \left( \frac{t-\tau}{\alpha} \right) d\alpha d\tau \]  

(3)

Thereinto: \( C = \left| \psi(\omega) \right| \) d\( \omega \) \( \psi(\omega) \) is Fourier transform of \( \psi(t) \)

The function of Wavelet decomposition at level 5

Manifestation of the Pulse signal (figure 2) \( S = a5 + d5 + d4 + d3 + d2 + d1 \)

The original and denoised signals are as shown in figure 3 and figure 4.

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Figure 3. Health Manifestation of the Pulse Signal before Wavelet Transform and the Signal after Wavelet Transform.

Figure 4. Manifestation of the Pulse of CVD Signal before Wavelet Transform and the Signal after Wavelet Transform.

4. The Feature Extraction of Manifestation of the Human Pulse signal

Figure 5. Detail signal at level 6 of health Manifestation of the Pulse after Wavelet Transform.

Figure 6. Detail signal at level 6 of Manifestation of the Pulse of CVD after Wavelet Transform.

Figure 7. Frequency domain diagram of detail signal at level 6 of health Manifestation of the Pulse after Wavelet Transform.

Figure 8. Frequency domain diagram detail signal at level 6 of Manifestation of the Pulse of CVD after Wavelet Transform.
In order to distinguish the pulse signals of the normal from the disease ones for feature extracting, in this paper, the authors proposed a method based on the singularity theory and the multi-scale resolution character of the wavelet transform. The authors applied Wavelet analysis technique and the theory of classical Manifestation of the Pulse in TCM to analyse the Manifestation of the Pulse signal feature of CVD patients, then do precautionary examine aiming at CVD, especially, thrombus and arterial sclerosis. The extraction of the characteristics of Manifestation of the Pulse Signal was mainly done basing on the Wavelet Packet decomposition. In detail, the paper mostly applied the Detail signal at level 6 after Wavelet Transform to reveal Manifestation of the Pulse signal feature of CVD patients caused by hyperviscosity and arterial sclerosis (refer to figure 5-figure 8). Singular signal often carries a lot of important information. Unlike Fourier analysis, the wavelet transform has good local properties in time domain and enjoys good time-frequency localization features, and it is convenient to process the non-stationary signal[6]. The wavelet transform technique is also adapted to processing the brim signal and the sudden signal. So, this technique has a good perspective in CVD detection and diagnosis.

5. Pattern Recognition of Manifestation of the human Pulse signal based on NN
RBF neural network has only one hidden layer [7]. Hidden layer take Radial basis function as its output characteristic. The weights of input layer to hidden layer have been defined as 1 and it is fixed. The weights between output node and hidden layer can be adjusted. So the output is weighted adding of hidden layer. The numbers of input layer neural cell (n) is equal to input vector dimensions (x∈R^n), the numbers of output layer neural cell (m) is equal to output vector dimensions (y∈R^m). Input layer neural cell and hidden layer neural cell, hidden layer neural cell and output layer neural cell are completely connected respectively. The hidden layer neural cell has the local response characteristic to input. The function value is very small when x_p is far from x_c.

\[ R_i(x_p) = \Phi(\|x_p - c_i\|) \quad i=1, \ 2, \ \cdots , \quad (5) \]

The definition of the above norm \( \| \| \) is Euclidean norm, \( c_i \in \mathbb{R}_n \) is the prototype of input vector, viz, the centre of radial basis function \( \Phi \). The Gaussian function that \( \Phi \) usually takes

\[ \Phi(v) = \exp\left(-v^2 / 2\sigma^2\right) \quad (6) \]

\( \sigma \) is width function of Gaussian function. It can control the convergence rate of Gaussian function, viz, it can control the range of input response. The two parameters \( x_c \) and \( \sigma \) of the RBF neural network can be adjusted. It is the function of hidden layer that have nonlinear transformation with input value. And the function of output layer is that has linear combination with hidden layer output value, and gain the output of network at last.

6. Experiment and conclusion
The case swatch is divided into two groups, A and B, there are twenty people in each group. The group A is learning group, the group B is test group. There are ten people who are diagnosed as CVD and ten people who are normal to compare with each other. The feature parameter of group A was input to RBF neural network to train. The training is stopped when the output-accumulated error is less than 0.01. The test through group B makes clear that there are nine cases in the ten cases who have thrombus CVD is correctly diagnosed, the correct rate is 90%; There are six cases in the ten cases who have other symptoms, the correct rate is 60%; There are nine cases in ten cases who are healthy, the correct rate is 90%. If we add the quantity of swatch, the veracity will enhance. CVD patients are different with health persons in the range of Manifestation of the Pulse signal too.

It can be found that hemal elasticity of CVD patients is weakened, and blood stream is not smooth because of Blood hyperviscosity and arterial sclerosis. The above character can be revealed obviously by Frequency domain diagram of detail signal at level 6 Manifestation of the Pulse after Wavelet Transform. From the figures, we can see, the energy of low frequency domain is higher, it shows that hemal elasticity CVD patients is littler than health person. The Feature Extraction and Pattern
Recognition to Manifestation of the Pulse should be studied in-depth for the cause and reaction of CVD is complex.

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