A Classification Method of Heart Disease Based on Heart Sound Signal

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Abstract: At present, the number of people suffering from heart disease in China is growing, and in contrast, the growth of medical resources cannot cope with the needs of ordinary people for heart diagnosis. In order to cope with this situation, help average person to check his or her heart condition anytime and anywhere, and detect his own heart problems, it is valuable to develop a heart disease examination system that is easy to carry and easy to use. In order to realize the diagnosis of heart disease by heart sound, this paper proposes an analysis method to analyze and analyze heart sound signals, and try to identify several common heart diseases. The method first uses wavelet analysis to denoise the heart sound signal, and filters out noises unrelated to heart disease processing analysis, such as lung sounds and breath sounds. After filtering out the noise, analyze the sound characteristics of different heart diseases with power spectral density, then identify those heart diseases.

1. Introduction
Heart disease has long been a major threat to human health. In 2017, the prevalence of cardiovascular disease in China is on the rise. The estimated number of cardiovascular diseases is 290 million, including 11 million coronary heart disease, 5 million pulmonary heart disease, 4.5 million heart failure, 2.5 million rheumatic heart disease, 2 million congenital heart disease, and 270 million high blood pressure. In 2015, cardiovascular mortality remained the highest, higher than cancer and other diseases. 2 out of every 5 deaths are due to cardiovascular disease[1]. Faced with this trend, the diagnosis and prevention of cardiovascular disease is very important.

The traditional diagnostic method for heart sounds is that doctors use old-fashioned mechanical stethoscopes to judge the heart disease of patients with personal experience. Doctors need have considerable professionalism and expertise[2]. The huge patient population makes medical resources very scarce. In order to improve the efficiency of treatment and facilitate patients and doctors, automatic diagnosis techniques have emerged to help doctors diagnose.

However, most existing automatic diagnostic systems use ECG signals as a diagnostic basis [3], and there are few diagnostic methods for heart disease using heart sound signals. The main defect of the heart sound signal relative to the ECG signal is that the ECG has more patient ECG signal data and research data as a diagnostic signal. The heart sound is due to the above-mentioned method of using the heart sound to judge the disease, resulting in a lack of a large database of heart sound signals, so that the diagnosis of heart sound signals lacks data support, and the accuracy cannot be verified. However, compared with ECG signals, the collection of heart sound signals is relatively simple, and the equipment used can be more convenient, simple and cheap [4]. This feature makes it easier to popularize automated diagnostic techniques and equipment.
This paper designs a method for processing heart sound signals for portable heart sound collection devices, and does some experiments to find a way to diagnose heart diseases by using heart sound signals.

2. Heart sound signal pre-processing

The problem that portable heart sound collection equipment will inevitably face is the noise interference problem. The heart sound signal collected in the relatively noisy environment relative to the hospital will inevitably have more noise interference, and there are some noise inside the human body, such as lung sounds, breath sounds, etc., these signals need to be filtered out before analyzing the heart sound signals. Common denoising methods include band pass filters, notch filters, wavelet threshold denoising, blind source separation, etc. After comprehensive consideration, this paper uses the threshold denoising method in wavelet analysis to filter out noise in heart sound signals[5-6].

Wavelet analysis base on general function analysis, Fourier analysis, spline analysis and harmonic analysis. It is also known as multi-resolution analysis. It has good localization characteristics in both time domain and frequency. It is often called "mathematical microscope" for signal analysis. In the past decade, the theory and methods of wavelet analysis have been widely used in professional fields such as signal processing, language analysis, pattern recognition, data compression, image processing, digital watermarking, and quantum physics[7].

Using wavelet thresholds to filter noise mainly involves three steps[8]. The first step is to select a wavelet basis function to perform wavelet decomposition on the signal to obtain a set of wavelet decomposition coefficients; in the second step, threshold the wavelet decomposition coefficient, and remove the noise wavelet coefficients; the third step will use the processed wavelet coefficient reconstruction signal obtain the denoised signal.

![Fig. 1. Wavelet denoising effect diagram](image)

In order to get the best denoising effect, it is necessary to screen the appropriate wavelet basis function, wavelet decomposition layer number and threshold. After experiment, I found using Daubechies wavelet as the wavelet basis function can get better denoising effect. Daubechies wavelet is a wavelet function constructed by the world famous wavelet analyst Ingrid Daubechies[9-10]. Generally abbreviated as db/N, N is the order of the wavelet. The dbN wavelet has good regularity, that is, the smooth error introduced by the wavelet as a sparse basis is not easy to be perceived, which makes the signal reconstruction process smoother.

In Fig. 1. we can find that the wavelet denoising denoising method completely preserves the characteristics of the heart sound signal while filtering out a large amount of clutter and noise.

3. Power Spectral Density

The power spectral density is the signal power in the unit frequency band. It shows the change of signal power with frequency, that is, the distribution of signal power in frequency domain. The power spectral density factor can represent the variation of signal power with frequency. It is often used in the expression and analysis of power signals. because there is no negative value of power, there is no
negative value in the longitudinal coordinates of the power spectrum curve, and the area covered by the power spectrum curve is equal to the total power of the signal[11]. The heart sound data used in this system comes from "The Art and Science of Cardiac Physical Examination". The sampling frequency of the book's data is 44100HZ. Figure 2 shows the power spectral density of a patient's heart sound who have atrial septal defect.

After the power spectrum of the heart sound signal is obtained, the heart sound power spectra of different heart diseases can be compared together. The two power lines in Figure 3 below are the heart sound power spectrum of a patient with cardiomyopathy and the heart sound power spectrum of a patient with non-obstructive hypertrophic cardiomyopathy. It can be found from the figure that a large part of the power spectral density diagram of the two is overlapping.

When the two patients had different diseases, the power spectra of the two patients were often quite different. Figure 4 shows a comparison of the heart sound power spectra of two patients with different heart diseases, one of whom suffers from congenital pulmonary artery reflux. The other one has a anterior myocardial infarction. It can be found that when the disease is different, their heart sound power spectrum is quite different.

For the same patient, the power spectrum of heart sound is consistent, that is, the power spectrum density of heart sound collected under different posture and different acquisition position is almost the same. Figure 5 shows the power spectral density of heart sounds collected in a patient with congenital pulmonary regurgitation when he in different postures.
4. Conclusion

According to the above characteristics, in the case of sufficient heart sound data, it is possible to classify some prominent heart diseases by comparing the power spectral density maps.

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