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Research Article

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The methodology of ECG feature extraction based on empirical mode decomposition

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ABSTRACT

It's essential for authentication to extract the feature of individual ECG signal accurately and efficiently. The common time-frequency analyses such as the classical Fourier transform, wavelet transforms and adaptive decomposition deem Fourier Transform as the ultimate theory. However, due to the paradox when analyzing the non-stationary signal, like false signals production and aliasing, so it desires for improvement for ECG signal feature analysis. The EMD (Empirical Mode Decomposition) is completely irrelevant to the Fourier analysis framework and it's effective to extract non-stationary and nonlinear signals. The ECG signal is decomposed into a series of basic mode components and a remainder term, and the acquisition of each basic mode of IMF depends entirely on the local time scale of signal without using any information. Improved EMD algorithm and the improved mirror extension method inhibited the use of end effect, improving the accuracy of the EMD.

Keywords: Biometrics, ECG, Empirical Mode Decomposition, IMF, End Effect

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INTRODUCTION

ECG as a specific physiological signal, with its universality, uniqueness and collection has become an important parameter of individual authentication. People use empirical mode decomposition processing ECG signals, such as removal of power frequency noise and inhibition of baseline drift[1,2]; It accord to the definition of the Hilbert transform to make the Fourier transform, then the signal instantaneous frequency can be obtained directly[3].In this study, it uses empirical mode decomposition to extract the QRS wave of ECG signal, using the improved mirror extension method to inhibited the end effect to realize the fast algorithm of ECG signal processing, which is effectively applied to individual authentication.

The EMD decomposition theory

There are many fluctuations in physiological signal model, simply using the Hilbert change calculate the instantaneous frequency is not suitable for the wave pattern, it is only to make the Hilbert transform to basic mode component can have physical meaning of instantaneous frequency. Empirical mode decomposition is a multi-scale analysis method, which is essentially a signal to be smooth, the result is the signal fluctuations or trends of different scale step apart to produce a series of different characteristic scale data sequences, each sequence is an intrinsic mode function, the decomposition of the intrinsic mode function component contains the local feature information of the original signal in different time scales. The lowest frequency of the intrinsic mode function usually represents the trend of the original signal or average[4].

Until meeting the stopping criteria of selection process. It is usually by limiting the processing results of two consecutive standard deviation between $h_{1(k-1)}(t)$ and $h_{1k}(t)$ to determine the size of the standard deviation of SD.

$$SD = \sum_{t=0}^{T} \frac{\left| h_{1(k-1)}(t) - h_{1k}(t) \right|^2}{h_{1k}^2(t)} \qquad (1)$$

In the formula, T represents the signal time span. Huang suggests the value of SD should take 0.2 to 0.3.The last remaining $x_n(t)=r_n(t)$ is the residual of original signal.

Thus, the signal $x(t)$ is decomposed into linear sum of N basic components $c_i(t),i=1,2,...,n$, and a remainder $r_n(t)$ by the EMD, that is

$$x(t)=\sum_{i=1}^{n}c_i(t)+r_n(t) \qquad (2)$$

From the above decomposition process, as it can be seen from the characteristic time scale of EMD, the smallest component of the basic model of the characteristic time scales in the signal is separated out, then separating out the characteristic time scales larger basic mode component. Therefore, the EMD can be seen as a set of signal adaptive high-pass filter.

A fast algorithm for ECG feature extraction based on EMD

From the above theoretical analysis and experiment results, the empirical mode decomposition is used to process non-stationary biological signal has an incomparable effect. However, because the algorithm contains local demand extremely, spline interpolation, boundary effect processing, double cycle steps, which results calculated amount is quite considerable, therefore, we must realize fast algorithm[5].

This study is based on empirical mode decomposition theory. As processing a large number of ECG signals based on empirical mode decomposition to find three important conclusions and puts forward several fast algorithm strategies:

(1) Due to the low order intrinsic mode function contains the change mode function, and high order intrinsic mode function contains the slow mode function, therefore, the first component of intrinsic mode function contains the high-frequency component of ECG. It is discovered that the spectrum analysis of ECG, the band is mainly concentrated in the 5~100 Hz. According to the literature [6], the QRS wave bandwidth is 0~37 Hz, the wave energy concentration in the vicinity of the 8~16Hz, as shown in figure 2.

(2) It is the most commonly with variance for the screening process to stop criteria, but the screening times can be set manually according to the signal characteristics.

(3) As this study aimed to treat ECG by EMD to position the QRS, therefore, it may exist in the regional of the QRS wave to empirical mode decomposition and the corresponding detection processing. It can be predicted through a next period before a period of QRS wave appears in the range.

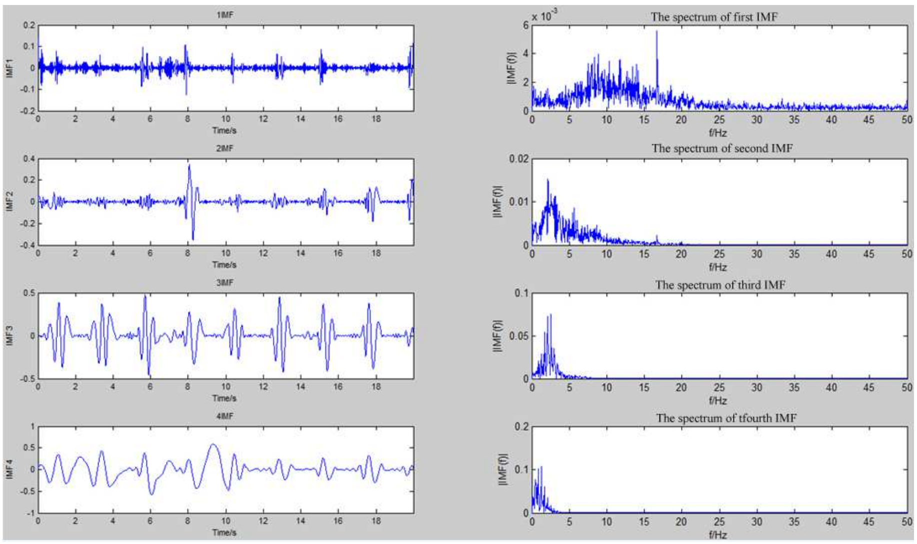

Fig. 2 (a) The spectrum analysis of No.103 ECG

According to the above three strategies, it presents a real-time localization algorithm, the steps are as follows:

(a)Initialization Former three cycles (approximately 700) of data in empirical mode decomposition, the first intrinsic mode function component is quite obvious at the same time, then calculating the intrinsic mode functions component of each cardiac cycle maximum, as to calculate the first two cardiac interval. If the proportion within [0.8, 1.2], initialization is considered successful.

(b)The main loop According to the previous interval to forecast for the range where the first intrinsic mode function components of the next cardiac cycle appear. This data segment is to be processed by the empirical mode decomposition, then finding the maximum intrinsic mode function components to get the cardiac cycle. In the time domain to obtain the maximum point R and the minimum point Q, Then entering the next cycle

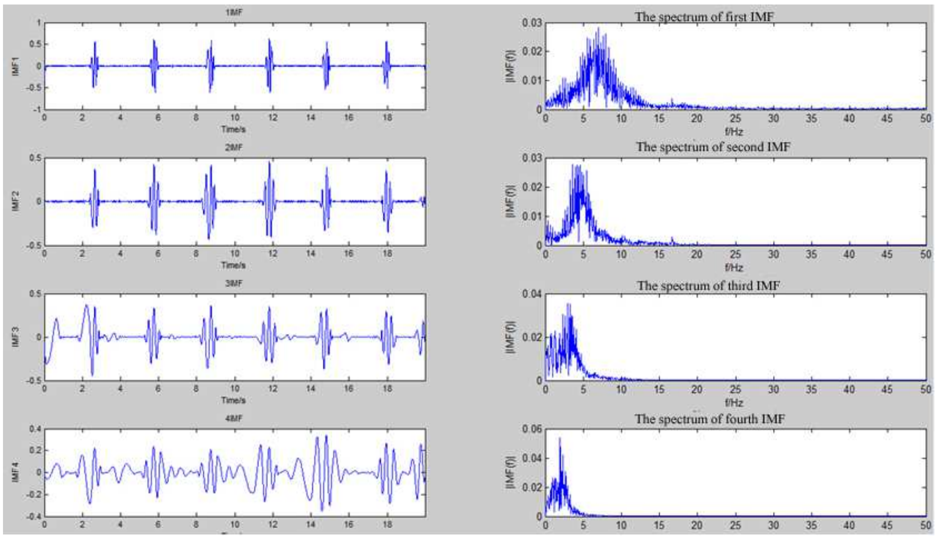

Fig. 2 (b) The spectrum analysis of No.109 ECG

The experimental results and analysis of a fast algorithm

In this study, the simulation platform is MATLAB 2011b,choosing the first lead of 48 ECG data which we can get from the MIT-BIT arrhythmia database to detect QRS complex, the test results are shown in table 1.

Table 1 MIT-BIH Database undetected Results

Data	Total beats	False beats	Undetected beats	Total false beats	Error rate(%)
100	2273	0	0	0	0
...	...	...	...	...	
106	2027	2	2	4	0.20
...	...	...	...	...	...
113	1795	2	0	2	0.11
...	...	...	...	...	...
119	1987	2	0	2	0.10
...	...	...	...	...	...
201	1963	13	14	27	1.38
...	...	...	...	...	...
209	3005	0	0	0	0
...	...	...	...	...	...
217	2208	3	1	4	0.18
...	...	...	...	...	...
231	1571	0	0	0	0
...	...	...	...	...	...
234	2753	0	0	0	0
Total	109499	255	193	448	0.41

Table 1 lists the test results of empirical mode algorithm to the first lead of 48 ECG data which we can get from the MIT-BIT arrhythmia database to detect QRS complex. The experimental data show that the algorithm to the characteristics of the database of ECG signal detection error rate is 0.41%, that is, the average correct rate is 99.59%.

To inhibit the end effects in the empirical mode algorithm

Serious end effect will influence the accuracy of EMD decomposition, therefore, the research to inhibit the end effects from EMD when it has attracted much attention[7]. The signal or its extreme extension is to be the border, which is now the most effective way to solve the endpoint effect. Improving mirror extension EMD core algorithm is as follows: First, calculating the extreme point of the signal, and the extreme point of the signal is symmetric extension, then the symmetric extension extreme point is compared with the original signal, so as to determine the new boundary of the signal according and the original signal was extended, so as to ensure that the new signal endpoint is extreme point signal; Then, a new signal to mirror extension and the EMD with the left point; Finally, according to the starting point and the length of the original to be truncated in the result of EMD method, the natural mode of the original signal to be obtained.

Improved mirror extension EMD in the application of ECG feature extraction

Through experiment with No.109, we get the maximal and minimal points of the original ECG signal, it is as shown in figure 5. After the mirror extension processing, we record the ECG signal for the new $x_{yan}(i)(i=1,2,...,n_{yan})$, and also record the starting positions $xstart_{yan}$ and the length Len of the original signal to facilitate the interception of the final decomposition. The original signal extreme points have been symmetrical extension and the correction signal is obtained as shown in figure 5.

Summary

In this study, the classical EMD decomposition is used to extract the features of the physiological signals, to solve the filtering incompleteness of the ECG signal in the traditional processing method and low degree of accuracy of feature point recognition. The EMD is used to decompose and reconstruct the original ECG signal to realize the QRS wave detection. Finally, we put forward the mirror extension method to overcome the end effect caused by EMD decomposition, which makes the feature extraction of ECG signal more accurate, personal identification rate higher.

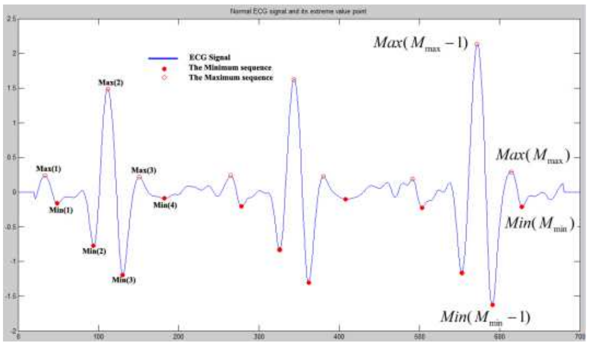

Fig.4 The extreme point of original signal

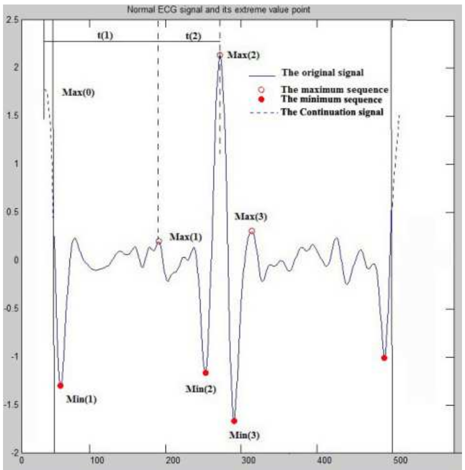

Fig.5 The correction signal

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REFERENCES

[1] N.E.Huang,Z.Shen,R.L.Steven: The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis. Proc R Soc Loud A,**1998**,p.903-995.

[2] B.W.Weng: ECG denoising based on the empirical mode decomposition. Proceedings of the 28th IEEE EMBS Annual International Conference. NewYork City,USA,**2006**.

[3] B.W.Weng: Baseline wander correction in ECG by the empirical mode decomposition. Bioengineering Conference,Proceedings of the IEEE 32nd Annual Northeast.**2006**.

[4] H.Fan:Non-stationary Signal Feature Extraction Method and Application (Science Press,China **2013**),p.125-151.

[5] W.J.Chen,M.Pan, Z.D.Zhao: *Journal of transducer technology*.**2006**(1). P.248-252.

[6] X.W.Cao,Q.K.Deng: *Chinese Journal of Medical Physics*,Vol.15(**2001**)No.1,(1).p.46.

[7] L.Yu,Q.Liu: *Journal of Wuhan University of Technology*,Vol.32(**2010**)No.10,p.151.