WAVELET TRANSFORMATION IN ELECTROCARDIOGRAM PROCESSING

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Abstract: *Decisions of problems during forecasting and early diagnostics of a heart attack, also in-time revealing of fatal infringements of heart rhythm, the prevention sudden coronary death are considered in the given work. Successful application biorthogonal wavelet-transform has allowed statistically characterize not only ECG-signals and wavelet-components but also to receive with authentic accuracy distinctive characteristics of two compared ECG-signals.*

Keywords: *electrocardiology, wavelet-transform.*

Introduction

In spite of current cardiology achievements in acute coronary syndrome diagnostics, mortality of patients after infarction heart attack is very high. Different methods of digital signal processing are applying in electrocardiography for discovering, selection and analysis of various parts of ECG. Among such methods wavelet transformation gives much promising results in time-frequency characteristics analysis of ECG.

Instructions for Manuscripts Preparation

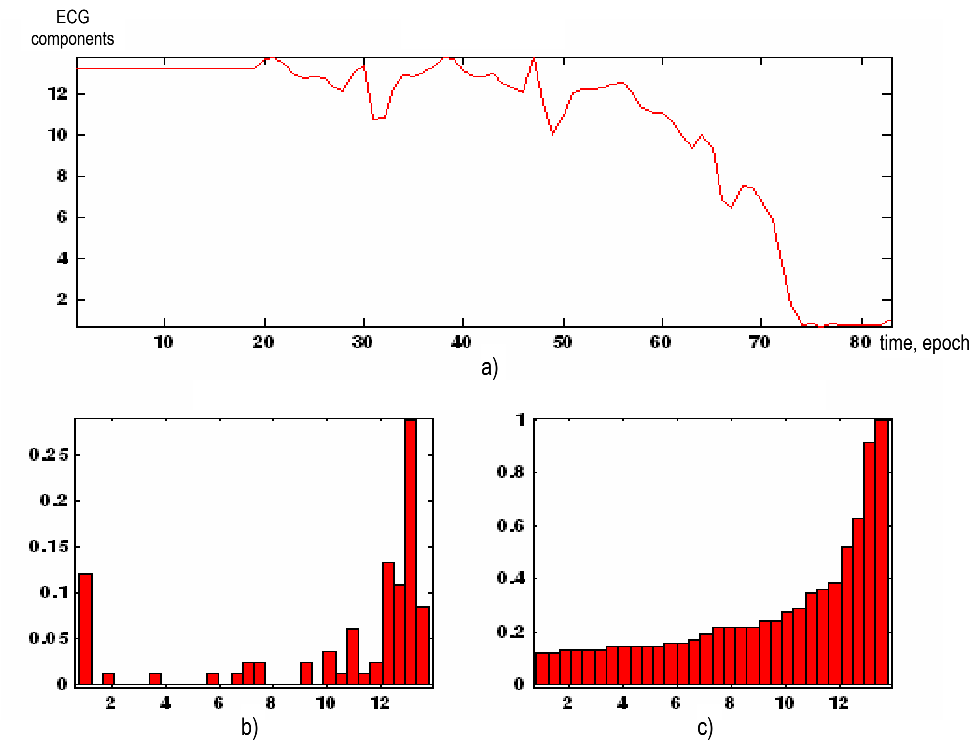
In current time is possible not only to establish and to determine of a heart attack but to make representation about size of a heart attack on an extent, and also about its "depth", i.e. about the greater or smaller distribution necrotic process in thickness of a wall of a myocardium.

Serial ECG-research enables to watch dynamics of process and to predict a situation. However the problem consists in the prevention sudden coronary death. The classical approach in electrocardiology is use of techniques of signal analysis in time area which have various applications (standard ECG-measurement, measurement of hard rate, dispersion of repolarization). However measurements of amplitude and duration the ECG components due to methods of ECG analysis in time area are not always sufficient for the description of all features of the ECG signal. For example, definition of late potential located in QRS complex, may not be executed with use of these methods. At the same time the heart rate analysis in time area gives the full information about behavior of RR-intervals and parasympathetic influence. But sympathetic ordering can not be appreciated on the basis of heart rate measurements in time area. Thus, using of analysis in both times and frequency areas together give universal results [Simson, 1992].

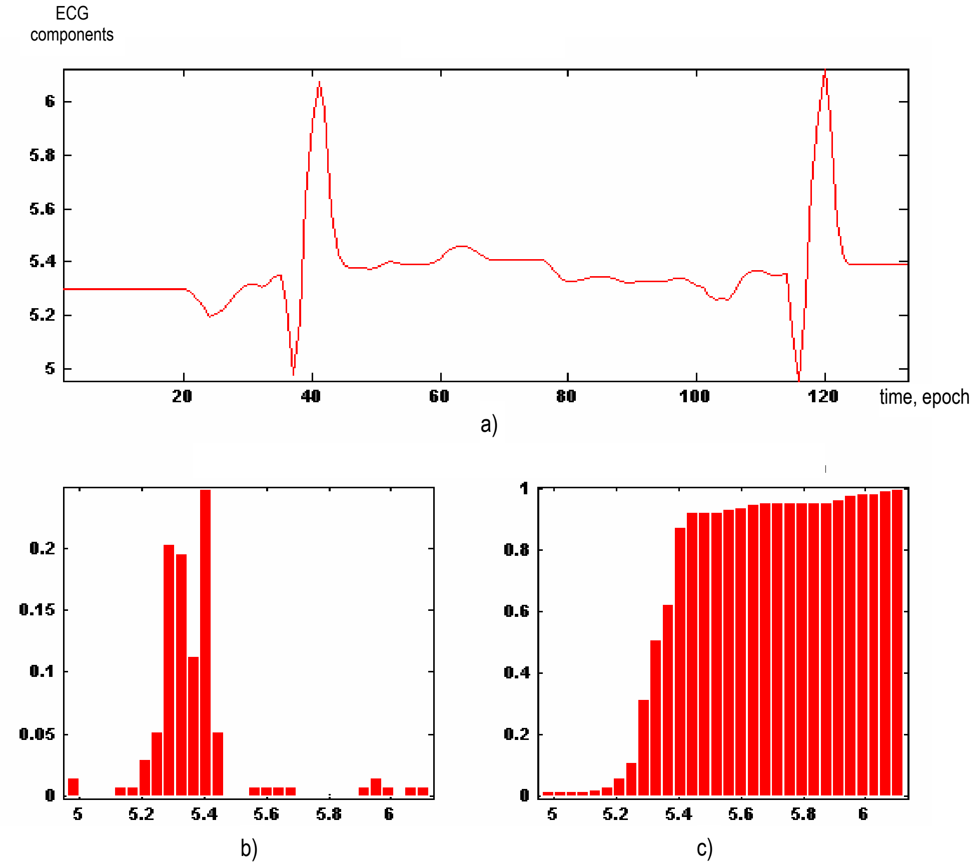
Frequency representation of the signal can be received with use of various techniques, including Fourier transform. Most frequently in electrocardiology it is used fast Fourier transform (FFT) which represent a time signal (theoretically it should be periodic) on infinite number of sinusoids. This set of sinusoids then is transformed in frequency area by using of amplitude and phase of each of these functions. Thus, FFT provides relation between time and frequency representation of the signal [Zareba, 1994, Khadra, 1993]. Digital ECG-signal is finite therefore it has precise borders. That is the reason of washing out of certain frequencies. In order to avoid this, during FFT it is applied to windowed Fourier transform for smooth reduction of ECG-signal border up to zero with removal of its intermittence. Restriction of this approach is a reduction of frequency resolution and decreases quality of definition of ECG-signal frequencies. Other inevitable restriction of Fourier transform is – it does not allow determining exact position of frequency components in non-stationary ECG-signal. For example, *QRS*-complex is high-frequency component whereas *T* peak contains low-frequency components. For non-stationary signals, whose spectral content change in time, Fourier representation is not appropriate. The wavelet transform (WT) provides varying time and frequency resolutions by using windows of different lengths [Polikar, 1999]. A key advantage of wavelet techniques is the variety of wavelet functions available, thus allowing the most appropriate to be chosen for the signal under investigation. This is in contrast to Fourier analysis which is restricted to one feature morphology: the sinusoid [Watson, 2005]. Everyone wavelet has the certain duration, time position and frequency band. Wavelet-parameters corresponds to ECG-components on a certain time interval and frequency band [Cain, 1985, Dickhaus, 1994, Дремин, 2001].

72 patients in the moment before start of heart attack were selected for the analysis. From them 48 electrocardiograms was from of patients who will die after heart attack and 25 will survive with the same diagnosis. Further, each of received digital ECG-signal was transformed by seven discrete wavelet types: Daubechies wavelet, Symlet wavelet, Haar wavelet, Coiflet wavelet, biorthogonal wavelet, reverse biorthogonal wavelet, discrete approximating Meyer wavelet. Each type, in turn, is broken on seven subspecies.

The most informative WT for the analysis of 1 standard lead on ECG-signal appeared biorthogonal wavelet (see pic.1,2).



Pic.1. Scalogram a), its histogram b) and cumulative histogram c)
of 1 lead on ECG of patients who will die after heart attack



Pic.2 Scalogram a), its histogram b) and cumulative histogram c)
of 1 lead on ECG of patients who will survive after heart attack

Comparison of wavelet-components dispersions allows as to distinguish ECG-signals statistically for patients who can die or can survive after heart attack and to determine a level of mortality risk from a heart attack at the earliest stages.

Conclusion

Analysis of ECG in time area by biorthogonal wavelet represents the new effective approach to definition of quantitative distinctions of signals for patients who have acute coronary insufficiency during early diagnostics and acute coronary syndrome and preventive maintenance of sudden coronary death. As application of wavelet-transform in ECG analysis – rather new area of research, many methodological aspects (mother wavelet choice and scale) demand the further researches for increase of clinical efficiency. Diagnostic and predicting importance of this technique in electrocardiology demands large clinical researches.

Bibliography

[Simson, 1992] Simson M.B. // Circulation.- 1992.- Vol. 85(Suppl).- P1145-1151.

[Zareba, 1994] Zareba W.et al.// J. Electrocardiol.- 1994.- Vol. 27(Suppl).- P. 66-72.

[Cain, 1985] Cain M.E. et al. // Am. J. Cardiol.- 1985.- Vol. 55.- P. 1500-1505.

[Khadra, 1993] Khadra L. et al. // J Med Engineering & Technology.- 1993.- Vol. 17.- P. 228-231.

[Dickhaus, 1994] Dickhaus H. et al. // Meth. Info Med.- 1994.- Vol. 33.- P. 187-195.

[Дремин, 2001] Дремин И.М. и др. // УФН.- 2001.- Т. 171, N 5.- С. 465-501.

[Polikar, 1999] Polikar R. The story of wavelets, in Physics and Modern Topics in Mechanical and Electrical Engineering, (ed. Mastorakis, N), pp. 192-197, World Scientific and Eng. Society Press, 1999.

[Watson, 2005] Watson J. N. et al. //Meas. Sci. Technol. -2005.- Vol.16. – P. L1–L6

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