A&QT-R 2004 (THETA 14) 2004 IEEE-TTTC-International Conference
on Automation, Quality and Testing, Robotics
May 13-15, Cluj-Napoca, Romania

WAVELET TRANSFORM BASED CHARACTERISTIC POINTS DETECTION ON ECG SIGNALS

Zoltán Germán-Salló

“Petru Maior” University, Tg-Mures, Romania, str Nicolae Iorga nr 1
fax:0265-262275, zgerman@upm.ro

Abstract

This paper briefly introduces theory of wavelet transform and shows a few promising applications in ECG signal processing, as noise suppression , baseline wandering removal, ECG characteristic points detection. With the multiscale feature of WT's, the QRS complex can be distinguished from P or T waves, noise, baseline drift, and artifacts. Various morphologies are excited better at different scales.

Keywords: wavelet transform, ECG signal parameters,QRS detection

1.Introduction

To analyze any finite energy signal $f(t) \in \mathbf{L}_2(R)$, the continous wavelet transform (CWT) $(W_\psi f)(s,\tau)$ of the signal $f(t) \in \mathbf{L}_2(\mathbf{R})$ [1] is:

$$(W_\psi f)(s,\tau) = \int_{-\infty}^{+\infty} f(t) \cdot \frac{1}{\sqrt{s}} \cdot \overline{\psi\left(\frac{t-\tau}{s}\right)} \cdot dt \qquad (1.1)$$

the dyadic discrete wavelet transform:

$$(W_\psi f)(2^j, k2^j) = < f(t), \psi_{j,k}(t) > \qquad (1.2)$$

The recognition of almost all ECG parameters is based on a fixed point identifiable at each cycle. R-peak is suitable for use as the datum point, because it has the largest amplitude and sharpest waveform that can be extracted from ECG. The time and amplitude measurements can be performed when the apex of the R-peak is detected at each cycle.

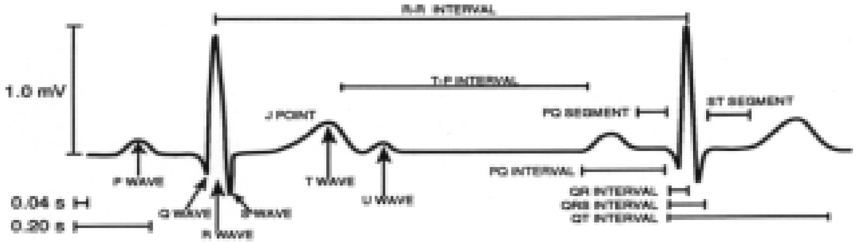

fig 1. The most important parameters of an ECG signal

2. Materials and methods

In all applications were used signals from MIT-BIH database with annotations from specialists (cardiologists), all methods were developed under Matlab (and Wavelet Toolbox).
At first, the signals from database were filtered, denoised and after baseline wandering was removed, using wavelet approximation. For baseline-wandering removal, at first, was identified the main low frequency component , using the properties of wavelet decomposition.

The parameters of the ECG signal are obtained by the wavelet decomposition dyadic tree. This tree decomposes the signal into the smooth (low pass) and detail (high pass) components. To estimate the said ECG parameters (QRS complex, T wave, P wave, locations and durations) in this work the following algorithm was used : Selecting a wavelet-transformed ECG block data, determination of the R wave location (as maxima) (scale 1) (which occurs at the zero crossing point between the most proeminent maxima), determination of R-R intervals, as R-R distances, determination of Q, S points as the first zero crossing point before and after R wave, elimination of the QRS from the signal to obtain the other parameters, determination of the P wave location (as maxima) (scales3,4) , and the P-Q distance, elimination of the P wave from the signal (same as step 5), determination of the T wave location (as the remained maxima) (scales 3,4), and S-T segments durations. This algorithm leads to determine the main parameters of an ECG signals.Were used over 27 files from the MIT-BIH database, signals containing normal sinus rhytms and signals with abnormalities in order to find the main parameters.

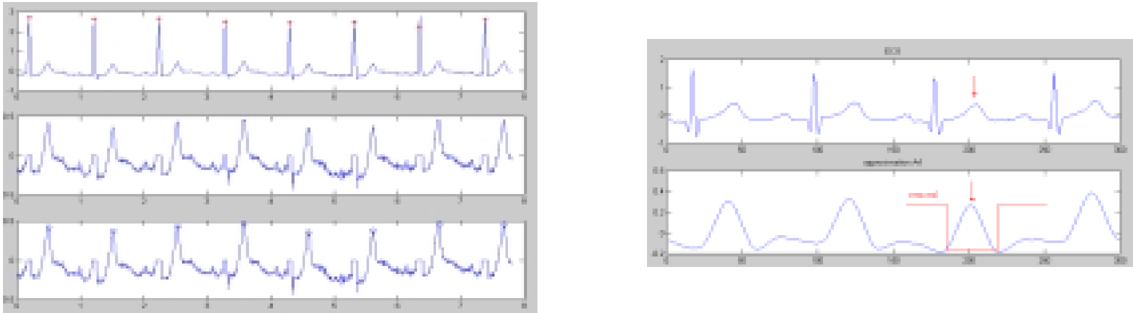

fig 5. R wave detection, QRS complex removal, T wave identification

3. Results

The results obtained (processing mainly ECG signals from normal sinus database) were compared with annotated files from ECG databases, and gave very promising results: R wave detection around 98%, R-R interval (HRV) determination 95%QRS complex detection over 91%, T wave detection/localization 88%, P wave detection/localization 78%. (27 files used from MIT-BIH database, signals were denoised and with the baseline drift removed)

4. Conclusions

The present study, based on biorthogonal wavelets, shown that the various morphologies of the ECG signals can be identified using wavelet decomposition at different scales.

5. References

[1] Aldroubi, A., Unser, M.: Wavelets in Medicine and Biology. CRC Press New York 1996

[2] Couderc, J.Ph., Zareba,W.: “Contribution of the Wavelet Analysis to the Non-Invasive Electrocardiology, University og Rochester, Rochester, New York USA 1999

[3] Mallat, S.: A wavelet tour of signal processing Academic Press London 2001

[4] Misiti, M., Misiti, Y., Oppenheim, G., Poggi, J-M.: WaveletToolbox. For Use with Matlab. User’s Guide. Version 2.The MathWorks Inc 2000.

[5] Provaznik, I.,Kozumplik, J., Bardonová, J., Nováková, M., Nováková Z. : “Wavelet Transform in ECG signal processing” , Departement of Biomedical Engineering Brno University of Technology , EuroConference BIOSIGNAL 2000

[6l] Walnut, D.,F.: An Introduction to wavelet analysis Birkhäser Boston 2002