Wavelet based approach to the adaptive analysis of electrocardiography signals.

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Abstract **The article discusses the problem of the automatic QRS complex detection in the electrocardiography signals. Among other approaches the Wavelet based algorithms are the ones of the most promising outcomes. Authors propose introduction of elements of adaptive techniques to the original scheme. The main aim is to achieve good SNR for different morphologies of QRS complexes both normal and dysfunctional cases, with the main focus on ventricular arrhythmias.**

Keywords **Wavelet transform, QRS detection, Electrocardiography, Signal processing.**

Article Digest

Automatic QRS complex detection task is the well known problem in the computer aided electrocardiography signal analysis. There are many different solutions of the problem discussed in the literature. The wavelet transform is one of the mathematical apparatus that produce still very promising results of a very high accuracy. It is very valuable property because of an object character (human being) and the importance of diagnostics carried out by physicians. It is a very important requirement to have an accurate diagnosis describing condition of a patient.

Continuous Wavelet Transform (CWT) can be described by formula (1).

$$W_{\psi,f,t}(u,s) = \left\langle f(t), \psi_{u,s}(t) \right\rangle = \int_{-\infty}^{+\infty} f(t) \frac{1}{\sqrt{s}} \psi^{*}\left(\frac{t-u}{s}\right) dt = f(t) * \overline{\psi}_{u,s}(t) \qquad (1)$$

where ψ is a wavelet function; f is an analysed function; t is a time variable, s and u are dilation and translation coefficients respectively. Parameter s domain is commonly narrowed down to set of 2^j where j is a scale factor. This operation makes Dyadic Wavelet Transform (DWT) which is less redundant and is characterised by the computation process much faster which is an essential advantage.

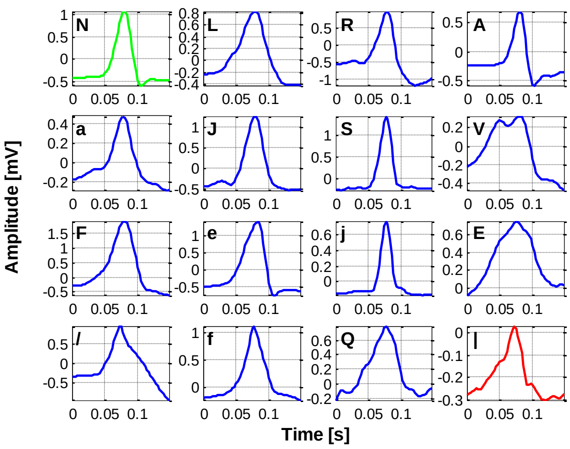

Fig. 1. Different types of beats.

From (1) one can see that the results depend on the wavelet used ($\psi_{u,s}$). The quadratic spline wavelet is commonly used in the analysis of electrocardiography signals. It assures good frequency parameters coincidence of general QRS complex and wavelet transform coefficients across characteristic scales. In fact QRS complex can posture heterogonous shapes according to many different arrhythmias (Fig. 1). Especially notable difference exists between normal shapes of QRS (**N** in Fig. 1) and ventricular shapes of QRS complexes (**V** in Fig. 1). The difference exists both in time and amplitude. Therefore one should expect different WT coefficient distribution. This fact is proved by the results presented in the Fig. 2. Coefficients characteristic for normal QRS complexes differs from ventricular QRS complexes both in terms of coefficients amplitude and scale subbands.

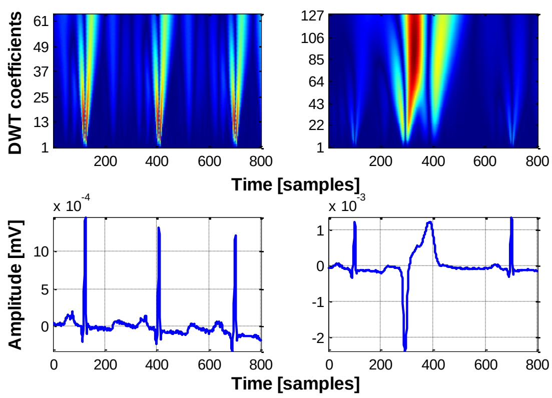

Fig. 2. CWT of different beat types. Normal sinus rhythm on the left. Premature ventricular contraction on the right.

There are two field of investigations, carried out by Authors independently. First one relays on the wavelet adopting to QRS complexes characteristic for different subject and for different arrhythmias. By means of parallel computations based on different wavelets it is easier to obtain robust, reliable results and also to distinguish probable arrhythmias that can be present in the signal. Second field of research, mentioned above concerns the dynamic selection of coefficient scales taken to the diagnostic process. As it is presented in the Fig. 2. different set of scales preserve information on particular QRS complex properties. Robust algorithm of selecting narrowed down set of scales characteristic for the QRS complexes reduces computational complexity making it easier to apply in the analysis procedure.