Automatized Analysis of Biomedical Signals

Andrej Korenić

Faculty of Biology and Mathematics, University of Belgrade
e-mail: kraner13@eunet.yu

Abstract: Precise and detailed shape analysis of biomedical signals, mainly cardiac and neurological, is of essential importance in clarification for diagnostic purposes and real time alert components of real time and alert systems.

1 Project Goal

The goal of this work was to create the algorithm that processes mainly electro cardiac and electro neurological signals in dynamic conditions. Methods used in biomedical signal analysis mainly concentrate on massive data blocks, with spectral - frequency distributions – Fourier analysis and more general Fourier analysis (like wavelets), then fractal analysis, e.g. changes of fractal dimensions, search for the attractors. Unfortunately, some phenomena do leak out: individual events that might be of substantial importance could be lost in massive data blocks or undetected by massive numerics. Nevertheless, there are trigger waves, that have specific shapes, which could be of lesser intensity, which perform important actions in various functions; there are various phenomena that happen in short bursts with specific shapes. For this reason, we need to be able to detect specific wave shapes even when they appear in single events and that is when we have to go back and use old way – description/automatized description of important features for their detection, classification, comparison, analysis. Some specific situations are demonstrated on the illustrations below.

Our solution offers improved applicability for the research and clinic use:

- Diagnose of changes in heart cycles:
    a) Arrhythmia – tracking during 24 hours in hospital and also monitoring more than one patient

    b) Detection of specific shapes of PQRST complex like infarct shape

    c) Automatic pulse-under-pressure tracking – the test of physical condition (managers, athletes,..)

d) Analysis of heart pressure

- Changes in EEG signals

a) Epilepsy detection

b) Analysis of sleeping waves in various conditions

- Real-time (RT) alert on mobile devices that monitor ECG or EEG, when patient doesn't have to stay still or to be perfectly calm.

This algorithm monitors these states better than previous tries showed, and it's easy to adapt it to any situation.

2 Method Description

We will discuss, as one rather characteristic example, an ECG signal.

Thus, electrocardiogram has the following elements:

1 P wave which represents depolarisation of both auricles (*atrium*)

2 PQ field has no electric activity, because it represents holding of impulse in AV (atrio- ventricular) knot

3 QRS complex represents depolarization of both ventricles where, for this example, the R pique should be detected

4 ST field has no electric activity, too

5 T wave represents repolarization of both ventricles at the end of the cycle

So, method requires P, T wave and Q, R, S, pique detection. I was inspired with SMARTA systems created by Aleksandar Jovanović and Group for Intelligent Systems at Faculty of Mathematics, University of Belgrade.

The algorithm is based on comparison of neighboring points or points that are separated with significant local extremes. The sensibility for R pique of this algorithm comes from calculation of increment – positive or negative – dynamic monitoring of the first derivative, which includes its own memory/comparison/detection functions, based on learning during initial calibration.

In the beginning this solution was sensitive to noise, and that defect was cured upgrading the algorithm to provide dynamic noise threshold settings and filtering. This change enables analysis in various conditions and applications, real-time alert, specific sensibility (soft, medium, hard), and enhanced interpretation of gained results.

3 Algorithm

The structure of our growing algorithm, currently includes the following components

- User interface
- Data acquisition
- Playback – real-time (RT)
- System tuning
- Noise reduction
- Shape analysis
    - trigo – trigonometry (calculations/ lowest point displacement..)
    - sshape – specific shape detection
- Numerics-Statistics

  (frequencies, standard functions, loc. minima, maxima, smoothing, ref/comparisons,..)
- Reporting
- Plotting

The implementation is done in MS C++ with standard libraries. It is still in the development especially towards the automatic shape learning- the module that will provide for acquisition of new characteristic shapes and their integration into the numeric model.

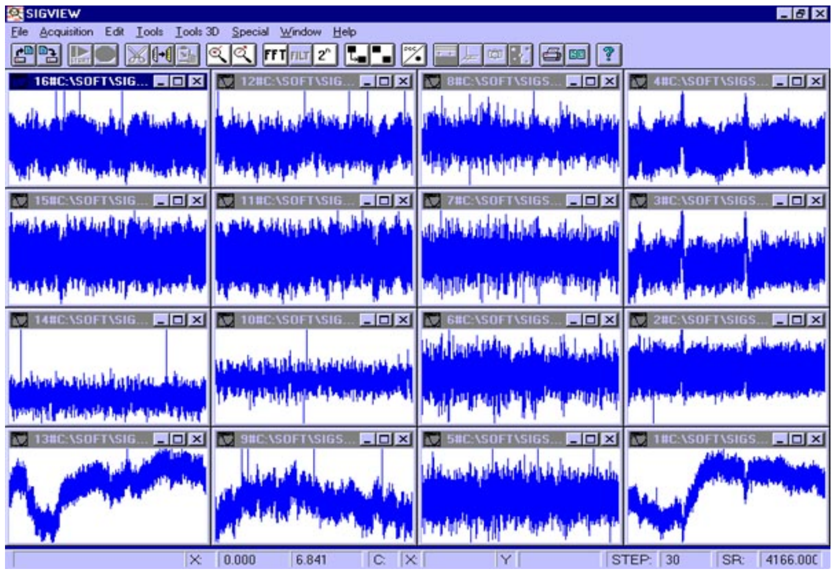


Figure 1
Unfiltered brain signals at higher acquisition rates (10 KHz)

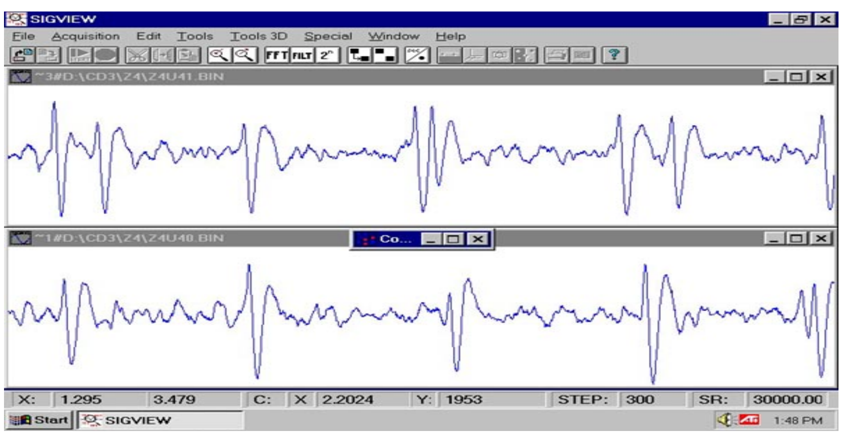
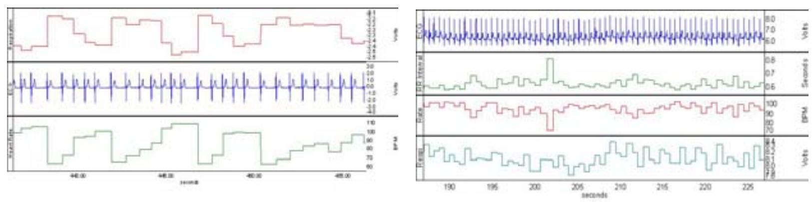


Figure 2
Simplex and Complex shapes - Individual neuron firing – at high acquisition rates (40 KHz)

Poligraphy - below we show a composition of various simultaneously recorded functions that include ECG, RR intervals, heart rate and respiration and some derivations.



References

[1] Anđus R. Pavle and associates: Experimental physiology I -with practical course- ; Faculty of Biology, University of Belgrade, 2000

[2] Guyton, C. Arthur, M.D. Textbook of Medical Physiology

[3] Jovanović Aleksandar, www.gisss.matf.bg.ac.yu