Information System Analysis of Heart Rate Variability

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***Abstract* – In this work is presented the software for heart rate variability analysis using methods of ECG and FPG signal registration and processing.**

***Index Terms* – electrocardiogram, photopletismography, heartbeat, cardio interval.**

I. INTRODUCTION

Implementation of continuous non-invasive methods of monitoring the health of the surveyed people on the base of acquisition and analysis of the ECG or PPG with the aid of the computerized technical means enables rapid identification of different heart spontaneous affections or monitoring functional status of the autonomic nervous system by heart rate variability analysis. Worldwide mortality from cardiovascular disease ranks first among human diseases. One of the routine examinations of any patient is to determine the frequency of cardiac contractions [1-3]. Analysis of variability in time of heart contraction frequency – cardiointervalography is used both for diagnosis of a diseases and examination of health people in order to assess the state of stress and level of adaptation in extreme conditions [4-6].

II. STRUCTURE OF THE INFORMATION SYSTEM FOR THE ANALYSIS OF THE HEART RATE VARIABILITY

Developed information system allows analysis of heart rate based on electrocardiogram or photopletismographic signal (Fig. 1) during signal recording more than five minutes [7-9].

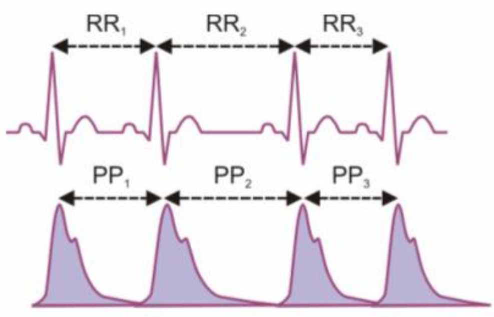

Fig. 1 ECG and PPG signal

Structure of the information system HRV consists of three core compartments (Fig. 2): Main Menu, File Manager and HRV Result Analysis.

The third section allows viewing HRV outcome analysis: real-time signal indicating extracted cardio intervals, the result of the string of the analysis of cardio intervals in time domain and temporal indicators calculation, the result of the string analysis of the cardio intervals in the frequency domain and calculation of spectral components.

Graphical interface of informational system for heart rate variability analysis is represented in Fig. 3.

The main menu contains a set of buttons with the help of which can be conducted the operation of the software: on/off the PC's USB port, start/stop recording signal in real-time, copying data files from SD-card memory device, printing the results and closing the program.

File Manager allows you to work with the patient data files: save signal in a file, opening a file, delete a file and sorting files.

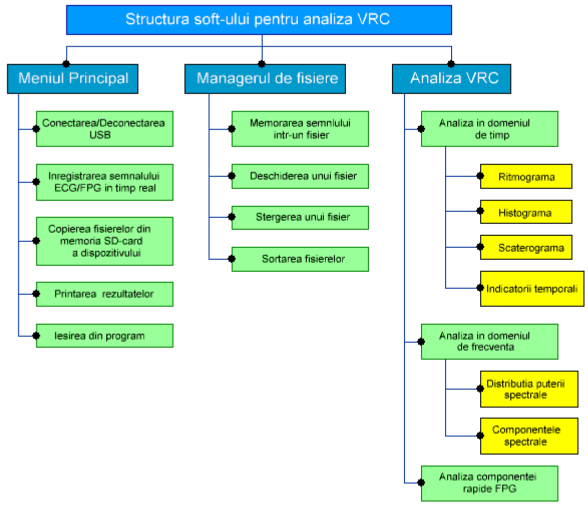

Fig. 2 Block diagram of software for analyzing HRV

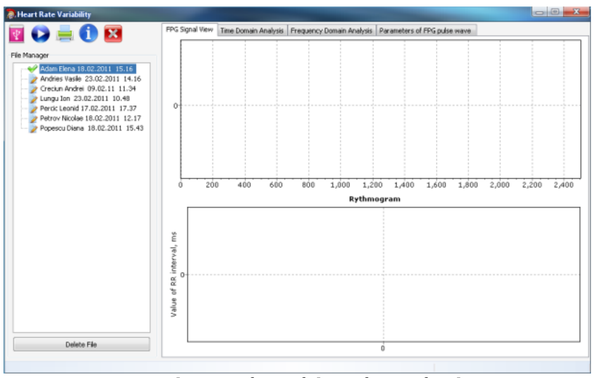

Fig. 3 Graphic interface of the software for the HRV

III. TESTING THE INFORMATION SYSTEM IN THE LABORATORY CONDITIONS

In the first stage of informational system work is necessary registration and visualization of the photopletismographic or electrocardiogram signal in real time as well as the extraction of the cardio intervals on the base of the memorized signal (Fig. 4).

After recording the signal with at least of 5 minutes duration and extraction of the string of cardio intervals can be performed the analysis of the cardio intervals in time domain and getting Rhythmogram (Fig.5)

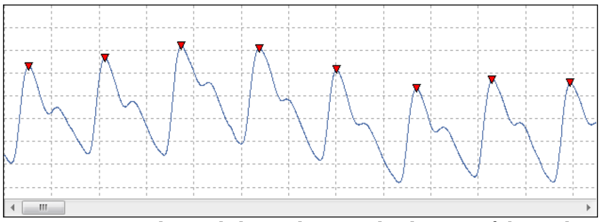

Fig. 4 PPG signal recorded in real time and indication of the cardio intervals.

, Histograms, Scattergram and temporal indicators: HR, RRmin, RRmax, SDNN, CV, RMSSD, pNN50, Mo, Amo, DRR, SI (Fig.6).

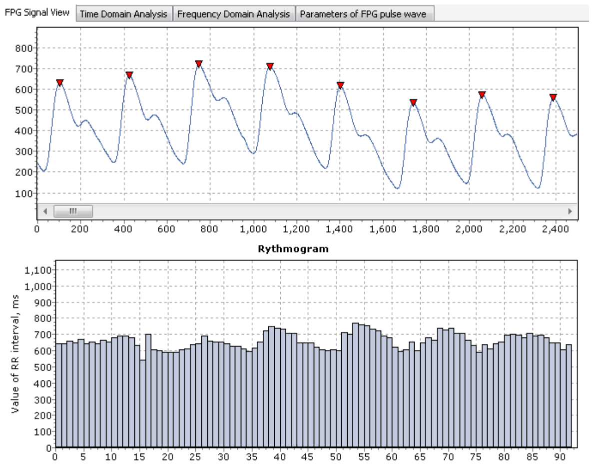

Fig. 5 Getting rhythmogram on the base of the string of cardio intervals

Rhythmogramma – displays interval duration dependence RR on the time recording interval RR. On the Axe abscissa is represented the time registration (seconds, minutes), but on the axis of ordinates is represented the RR measured interval duration (milliseconds).

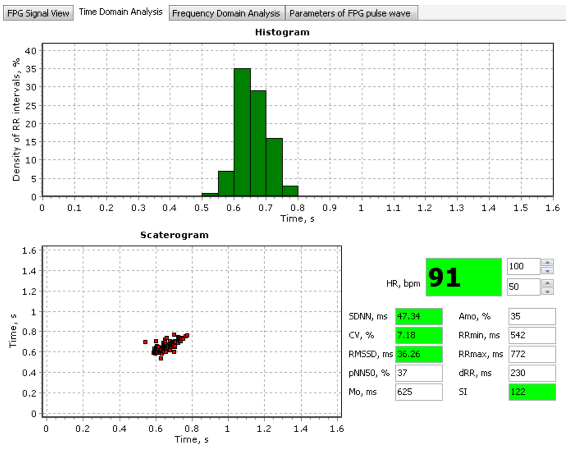

Fig. 6 Getting histogram, scattergram and temporal indicators

Histogram – represents the maximum number of RR intervals in a determined time interval. On the abscissa axis is represented time interval (seconds) but on the ordinates axis - density of the RR time intervals (%).

Scattergram - a two-dimensional representation of cardiac rhythm. On the abscissa axis is represented the size of RR_i (seconds), but on the ordinates axis is represented the RR_{i+1} interval (seconds). Table I contains the name of temporal indicators and measurement units.

Analysis of the string cardio intervals in the frequency domain involves obtaining a continuous cardio interval by applying cubic spline interpolation and then applying Fourier fast transformation (FFT) in order to calculate the distribution of the spectral power corresponding to the spectral components: Ulf, VLF, LF, and HF (Fig. 7).

Analysis of the spectral power density of the heart rate oscillations provides information on the power distribution in dependence upon the frequency of oscillations. To this fast Fourier transformation refers.

TABLE I. TEMPORAL INDICATORS

HR	Heart rate frequency (pulse) [beats / min]
RRmin	The minimum value of cardio intervals [ms]
RRmax	The maximum value of cardio intervals [ms]
SDNN	Mean square deviation [ms]
RMSSD	Quadratic mean difference characteristic [ms]
pNN50	The percentage of RR intervals which,(RR_i – RR_{i-1})>50 ms, reported on the total number of the intervals [%]
CV	Coefficient of variation [%]
dRR	The difference between the minimum and maximum value of the cardio intervals [ms]
Mo	Mode [ms]
Amo	Mode amplitude
SI	Stress index

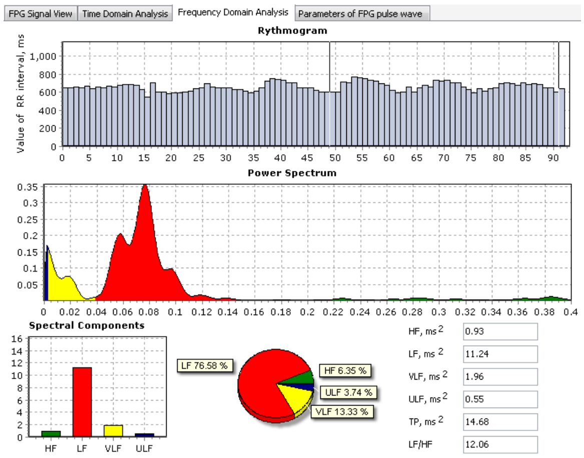

Fig. 7 HRV result analysis VRC in dependence upon the frequncy. Spectral components

Table II contains the name of the spectral components and the frequency diapason corresponding to each component.

TABLE II. SPECTRAL COMPONENTS

HF	Spectral power in domain of the high frequency	0,15-0,4 Hz (2-6,6 sec)
LF	Spectral power in domain of the low frequency	0,04-0,15 Hz (7-25 sec)
VLF	Spectral power in domain of the very low frequency	0,015-0,04 Hz (25-66 sec)
ULF	Spectral power in domain of the ultra low frequency	0,003-0,015 Hz (66-333 sec)

When the used method for investigating HRV is photopletismography at the same time can be performed an analysis of the photopletismographic signal by calculating the main parameters of the rapid component of the pulsating wave FPG (Fig. 8).

Table III contains the full name of the main parameters of the fast wave pulsating component FPG.

IV. CONCLUSIONS

Developed system allows recording and processing the electrocardiographic or photopletismographic signal in real-time, extraction of the cardio intervals on the base of the recorded signal at a long period of time (up to 24 hours), saving and performing heart rate variability analysis by analysis in time and in the frequency of the cardio intervals string obtained.

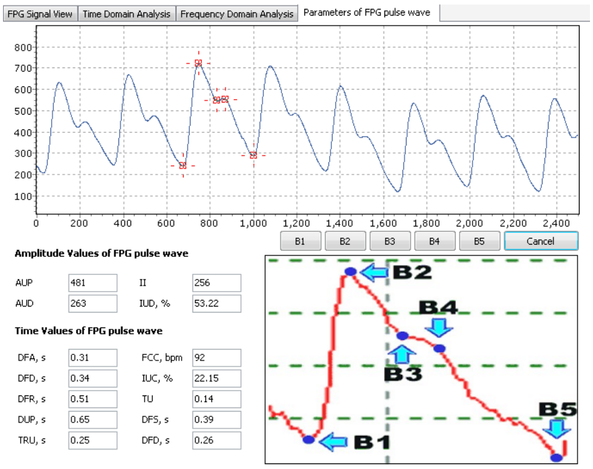

Fig. 8 Key parameters of the fast wave pulsating component FPG

TABLE III. KEY PARAMETERS OF THE FAST COMPONENT FPG

WPA	Wave pulsating amplitude
ADW	Amplitude of the decrotic wave
IH	Incesure height
IDW	Index of the decrotic wave
DAP	Duration of the anachrotic phase of the pulsating wave
DDP	Duration of the decrotic phase of the pulsating wave
DDP	Duration of the descent phase
DPW	Duration of the pulsating wave
TRW	Time reflection of the pulsating wave
FCC	The frequency of the cardiac contractions
IUW	Index of the upward wave
ET	Ejection time
DSP	Duration of systolic phase of heart rate
DDP	Duration of diastolic phase of heart rate

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