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METHODS FOR INCREASING THE RELIABILITY OF ANALYSIS FOR TREATMENT OF ELECTROCARDIOGRAPHIC SIGNALS

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Abstract: *Diagnosis of heart diseases through electronic processing and analysis of electrocardiographic signals for preventive control is the object of the study of this article. The condition of critically ill patients and people in extreme conditions are examined through the work of the cardiovascular system after long monitoring of the main parameters. For this purpose the most informative are rhythm analysis of electrocardiogram (ECG) and change of electrodermal activity (EDA). Electrodermal activity represents the change of electrical properties of the skin and characterized psycho-physiological and psychological state of the individual. The subsequent rhythm analysis of cardiological signal gives information on ventricular contractions of the heart muscle and the deviations from its normal QRS complexes and extrasystoles. The purpose of development is to provide methods for improving the accuracy of the analysis processing of ECG signals in order to diagnose cardiological disease during the building of a system for preventive control.*

Keywords: *electrocardiographic signal, monitoring, electronic system, cardiovascular disease*

INTRODUCTION

Electronic processing and analysis of electrocardiographic (ECG) signals is one of the most advanced computer procedures for diagnosing a heart disease. The removal of interfering factors and noise is the prerequisite of improving the methods and methodologies for processing ECG signals to eliminate or maximum interference suppression to improve the accuracy of the operation of extraction of diagnostic information.

Despite considerable variety of mathematical, statistical and computational methods for processing of electrocardiographic information the search and improvement of methods for analysis and diagnosis remains a priority in the development of medical science.

The electrical activity of the heart, measured by an electrode placed on the surface of the human body may be represented as a voltage generator of the electric dipole of the heart with amplitude of about 1 mV, and very large output impedance. It is accompanied by various artifacts and interferences - low frequency dref, extremely low frequency, occasional high frequency, networking, myographic and electrocardiographic interference.

The purpose of this development is to provide methods for improving the accuracy of the analysis processing of ECG signals in order to diagnose cardiological diseases in building a system of preventive control.

METHODS FOR ANALYSING OF CARDIOLOGIC SIGNALS

Integrated approach

Cardiovascular system maintains vital for the human health circulation. The work of the heart is a dynamic sequence of electromechanical phenomenon. It is subject to continuous monitoring and analysis of critically ill patients and persons in extreme conditions. In these studies the most informative parameters are the rhythm analysis of electrocardiogram (ECG) and the measurement of electrodermal activity (EDA).

The rhythm analysis is consisted in recognition of ventricular contractions of the heart and delimiting of normal QRS complexes and extrasystoles.

The removal and the recording of ECG signals are accompanied by a number of disorders. For their elimination or suppression methods and algorithms are determined by the purpose of the analysis.

There are three most common physiological processes: excessive agitation, muscle tension and electrodermal activity. Electrodermal activity in the human body leads to a permanent change in the electrical properties of the skin. This includes the conductivity of the skin, galvanic resistance, electrodermal response, response to the level of conductance of skin and skin conductivity. The resistance of the skin varies according to the state of the sweat glands in the skin. Perspiration is controlled by the sympathetic nervous system and skin conductivity and is indicative of psychological and physiological arousal. The autonomic nervous system excitement registers, unintended wobble - sympathetic then increases the activity of the sweat glands, which leads to increase in the conductivity of the skin. In this way the skin can be a measure of the emotion and response of the sympathetic nervous system. The activity of the skin can be changed in emotional stimulation and this activity can be used in therapy.

One of the most popular methods for the study of psychophysical phenomenon is the method of electrodermal activity.

In the limbs in humans various bioelectric signals showing the change in conductivity between two points in time. While registering signals through an electronic system it can trace the relationship between emotional state and sympathetic activity without identifying specific types of emotions. These changes affect to the blood flow, which reflects on the activity of the galvanic skin. The response of the skin and muscle tissue to external or internal irritants causes the variations in conductivity to several μS.

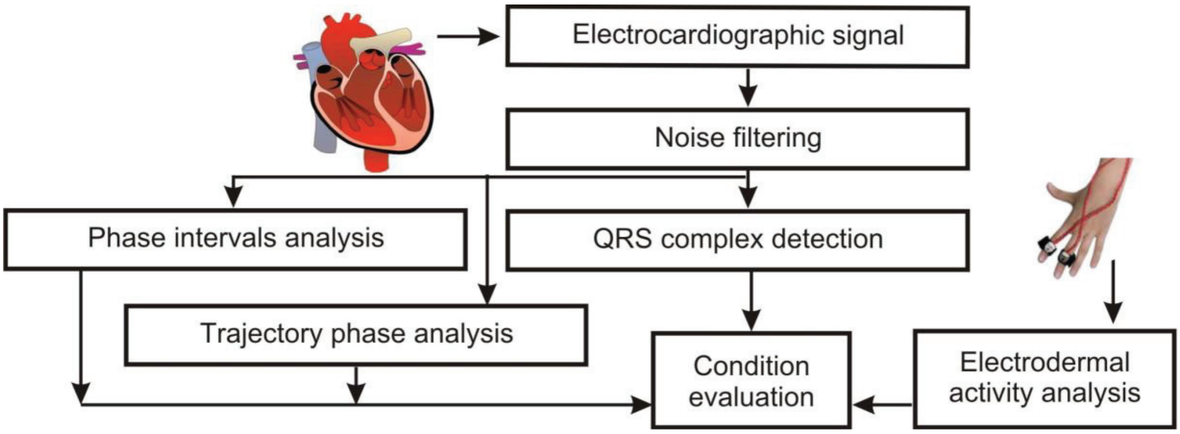

Figure. 1. Block diagram of an integrated approach for analyzing the ECG signal

The combined changes that occur between electrodermal response and electrodermal potentials create electrodermal activity. Galvanic skin resistance is detectable by recording the electrical resistance between the two electrodes when the current flows between them. The electrodes are placed at a distance of 25mm. The resistance varies depending on the emotional state of the patient. The galvanic potential of the skin is the voltage, which is measured between the two electrodes, when there is no externally applied impact. The measured voltage is increased or decreased and reflects the changes in the emotional state of the subject.

Often the prolonged excessive physiological arousal and stress is the cause of many psychophysiological problems. This excitement can be caused by stress.

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Phase intervals method

The received general diagnostic information is used in processing the ECG signal in the frequency domain. The spectral analysis assesses the frequency, amplitude and initial phases of the harmonic components of the signal.

The basis of spectral analysis is a Fourier transform that represents each periodic function y(t), decayed into trigonometric form (1).

$$y(t) = a_0 + \sum_{n=1}^{\infty}\left(a_n \cos\frac{2\pi t}{T_0} n + b_n \sin\frac{2\pi t}{T_0} n \right) \qquad (1),$$

Where $T_0 = 2\pi/\omega = 1/f$ is the period of function; ω is circular frequency and f is the frequency, which is measured in Hz.

Trajectory phase method

The behavior of dynamic systems specified by a limited set of parameters of the state $x_{1,\dots,}x_N$, is carried out on a phased portrait where the analysis takes place in the N-dimensional space with coordinates $x_{1,\dots,}x_N$. The phase portrait of the deterministic system is described by three differential equations as shown in (2).

$$\left| \begin{aligned} \frac{dx_1}{dt} &= -\sigma x_1 + \sigma x_2' \\ \frac{dx_2}{dt} &= -x_1 x_3 + r x_1 - x_2 \\ \frac{dx_3}{dt} &= x_1 x_2 - b x_3 \end{aligned} \right. \qquad (2)$$

When analyzing the ECG signal in the phase plane it is given the assessment of speed indicators on the electrocardiogram. The contractile function of the myocardium in the phase space is assessed by amplitude and its time derivation $\dot{y}(t)$. The diagnostic value of the method is the use of speed characteristics of the research process, which is confirmed in studies of cardiologists.

The computer analysis of the phase portrait of the ECG signal in the coordinates $y(t)$ and $\dot{y}(t)$ allows to the form to be evaluate with high accuracy of individual fragments in the cardiographic signal and to separate the deviations, which are usually not reflected by the doctor in the traditional analysis of ECG in the temporary area.

The image of the ECG in the phase coordinate system is described by differential equations (3).

$$\left| \begin{aligned} \dot{x}_1 &= x_2 \\ \dot{x}_2 &= F(x_1, x_2) \end{aligned} \right. \qquad (3),$$

Where $x_1 = y(t)$ is the amplitude of the ECG signal during the time, $x_2 = \dot{y}(t)$ is its first derivative and $F(x_1, \mathrm{x}_2)$ is a nonlinear function of change.

Dividing the two equations of the system an equation is obtained, in which there is no time explicitly (4):

$$\frac{dx_2}{dx_1} = \frac{F(x_1, x_2)}{x_2} \qquad (4),$$

The solution of expression (4) is represented in the form (5), then transfer in the phase plane $y(t)$, $\dot{y}(t)$ – expression (6).

$$x_2 = \Psi(x_1) \quad (5),$$

$$\dot{y}(t) = \Psi\left(y(t)\right) \quad (6),$$

An analysis of ECG signals and identification of QRS complex as one of the most significant and informative subparts of the cardiogram include those described methods and allows to develop algorithms and programs for analyzing signal in order preventive control.

Algorithm for detecting the QRS complex

The identification of the QRS complexes as part of the ECG signal the network disturbances affect to the accuracy of the algorithms during the search of different biological signals. One of the proven methods to eliminate network interference is creeping averaging of samples per 20 ms subinterval during the repetition of 50 Hz network signal.

The detection of QRS complexes during the period of study is performed by the method of Dotsinski and includes:

1. Determination of the first derivative of the selected divert of ECG signal

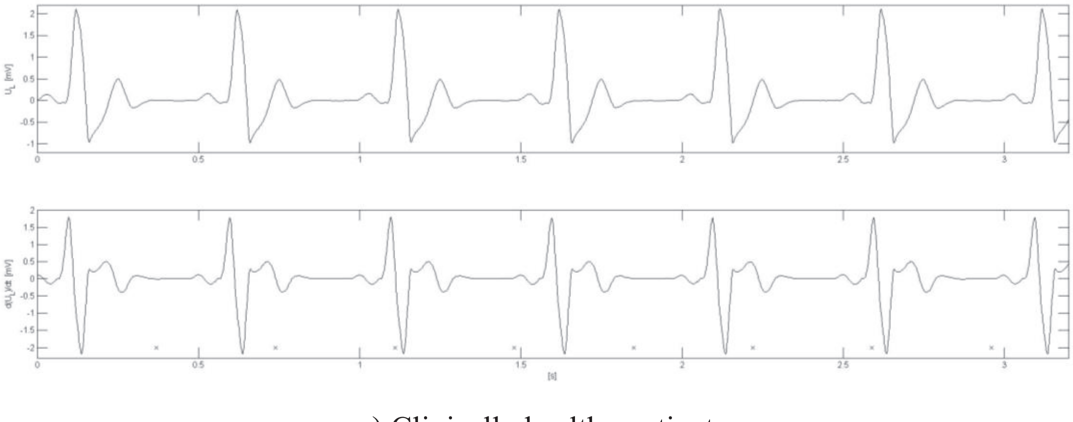
2. Formation of differences between the discrete locates 20 ms from one another and the comparison by sign and amplitude compared to standard deviation embedded with a minimum value 0,2 mV and a maximum value 1,6 mV.

3. Detecting a QRS complex in the subintervals with duration of 200 ms while continuously adaptation of variable comparative threshold in the range of 200 to 1000 ms with 12.8%. After 1000 ms the comparative constant decreases 2-fold.

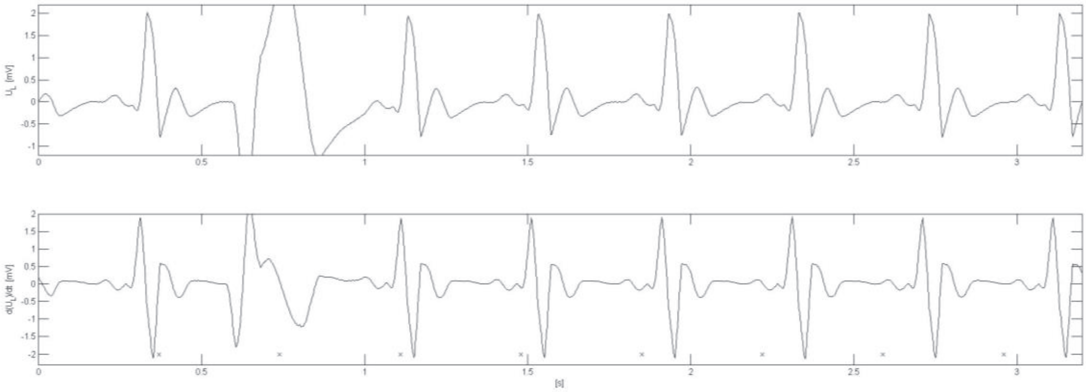
After yjr detection of the signal it is conducted the analysis of received QRS complexes then determine their pathologies and recommended control for subsequent treatment.

RESULTS

In the laboratory of Medical electronics that is chair of electronics through apparatus CARDIOSIM II ECG Arrhythmia simulator and ECG Implementation of the TMS320C5515, Texas Instruments, are studies for these cardiac symptoms: premature ventricular contraction, ventricular fibrillation (ventricular fibrillation) and normal heartbeat with premature ventricular contractions that determine disease myocarditis. The results were analyzed with the developed program AMEG in program environment MATLAB and are presented in Figures 2, 3 and 4.

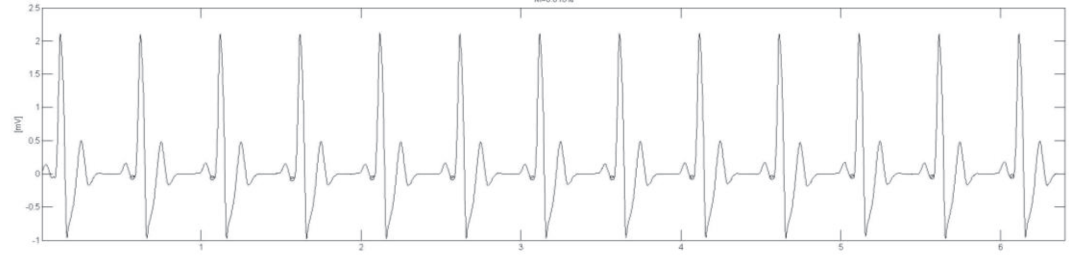


a) Clinically healthy patient

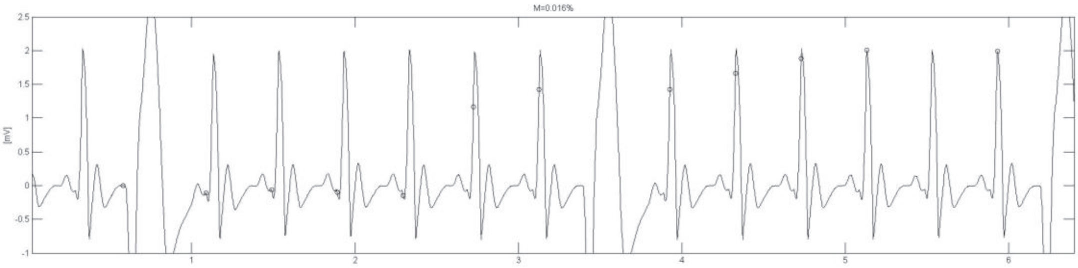


b) Patient with premature ventricular contraction

Figure.2. Results of L and its first derivative

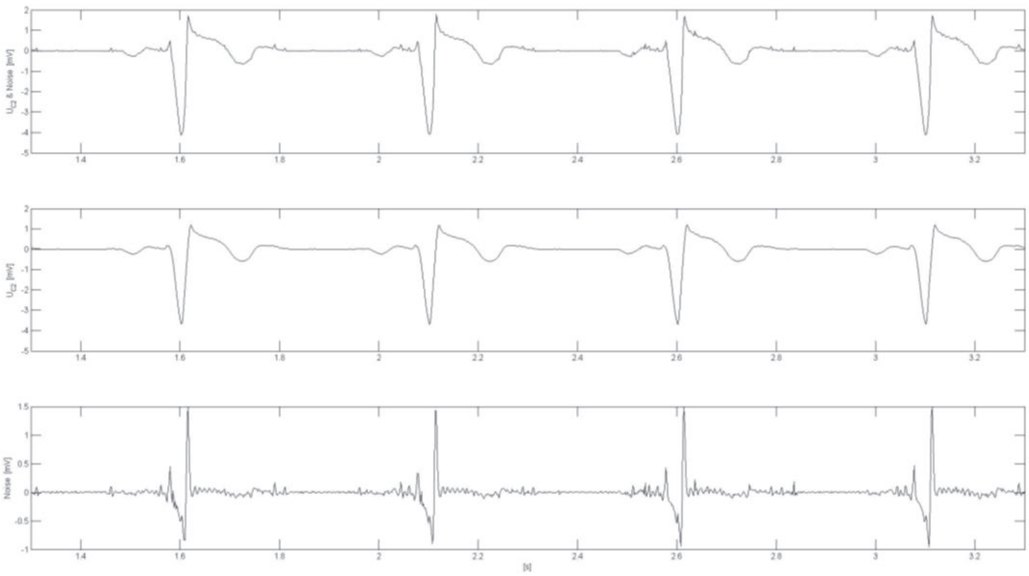


a) Clinically healthy patient

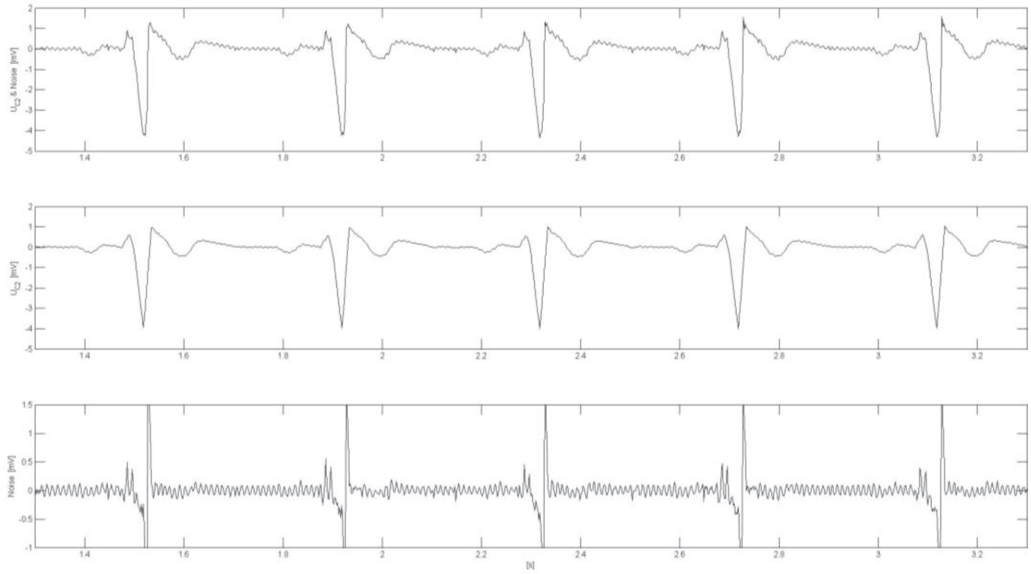


b) Patient with premature ventricular contraction

Figure.3. Results of the L with the detection of the beginning of the QRS complex



a) Clinically healthy patient



b) Patient with premature ventricular contraction

Figure.4. Results of thoracic outlet C2 with removal of network noise

The signals are traced in the time interval and the recording lasts 10s with the aim of recurrence of individual symptomatic indicators and their location. The sample rate ADC is 500Hz, the resolution – 4,88μV. The analysis and study of the specifics of different parts of the ECG signal is recorded and changes occur in different structures.

CONCLUSION

Methods for analyzing the ECG signals to improve accuracy in the diagnosis of cardiac diseases and building a system of preventive control are presented.

It has an algorithm to detect the QRS complex.

It was created in the software program AMEG in the program MATLAB for detection and analysis of the QRS complex and eliminating network noise.

The ECG signals were tested on clinically healthy and pathology patients for the purpose of comparative analysis of the recorded cardiac disease and their response.

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