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VISUALIZATION OF THE HEART WITH HELP OF CARDIOGRAPHIC EQUIPMENT

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Abstract. This study presents the problems associated with cardiovascular diseases (CVD) and Two-component FitzHugh – Nagumo model and heart condition imaging algorithm are considered. Aspects of work aimed at designing and developing of the hardware and software complex based on the information obtained with the help of an electrocardiograph
Keywords: Functional diagnostic, electrocardiographic, cardiovascular system, transmembrane potential.

According to World Health Organization (WHO), over 17 million people worldwide die annually from cardiovascular diseases (CVDs). Moreover, according to WHO, an estimated number of almost 23.6 million people will die from CVDs by 2030. In 2012, 1 million 232 thousand 182 people died from CVDs in Russia (Fig.1) [1-3].

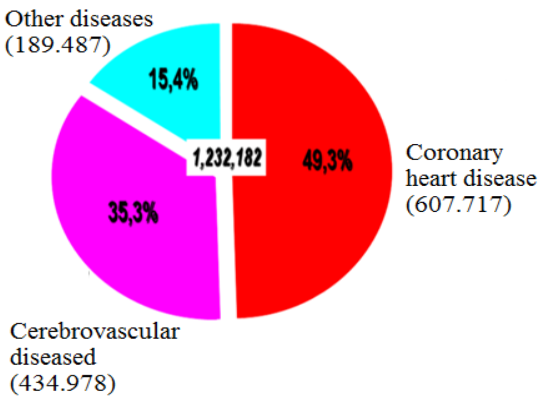

Fig. 1. WHO report on CVDs for 2008

Electrocardiography is a set of methods and techniques for recording and studying of electric fields generated by the heart during its work. Electrocardiography is an inexpensive but valuable diagnostics method in cardiology. The direct result of electrocardiography is an electrocardiogram (ECG). ECG is a graphic representation of difference of potentials, resulting from the heart work and projected on the body surface. Appearing at a certain moment of the heart work vectors of action potentials are averaged and recorded on the ECG. The first cardiographic studies were carried out in the late 19th century by the Scottish scientist Alexander Muirhead [4, 5].

In order to simulate the process of excitation propagation, one of the excitable medium models [6], a two-component FitzHugh – Nagumo model is suggested. This model includes a fast variable u, which corresponds to membrane potential in the full model, and a slow variable v.

$$\frac{\partial u}{\partial t} = -ku \cdot (u-a) \cdot (u-1) - uv + \Delta u,$$
$$\frac{\partial v}{\partial t} = -\left(\varepsilon_0 + \frac{\mu_1 v}{u+\mu_2}\right) \cdot (v + ku \cdot (u-a-1)),$$

where (x, y, t) $\varepsilon,\ \beta,\ \gamma,$ are model parameters, and ε parameter is assumed to be small: $\varepsilon << 1$. Communication between cells of the heart muscle is described by the diffusion terms in the equations, and the dynamics of a single cell – by the reactionary nonlinear terms of equations. After a series of experiments, the model parameters of the system were determined for better reflection of the cardiac muscle properties: $C = 1.0,\ \varepsilon = 0{,}1\ \ \beta = 0.004,\ \lambda = 0.03 k = 8.0, \varepsilon_0 = 0.01, \mu_1 = 0.2, \mu_2 = 0.3, a = 0.15$

The proposed method of assessment of the patient's condition is based on the combined use of the methods of analysis, modeling and imaging of cardiographic information that allows combining the solutions of direct and inverse problems of electrocardiography within one examination. The main advantage of such a combination is the ability to use the modeling results for the analysis of patient's condition. A hardware and software complex is suggested to be developed, within the concept of assessing the condition of the cardiovascular system (CVS), on the basis of the laboratory No. 63 of the Institute of Non-Destructive Testing, in order to implement the modeling of heart excitation propagation. HSC operating procedure is shown in Fig. 2.

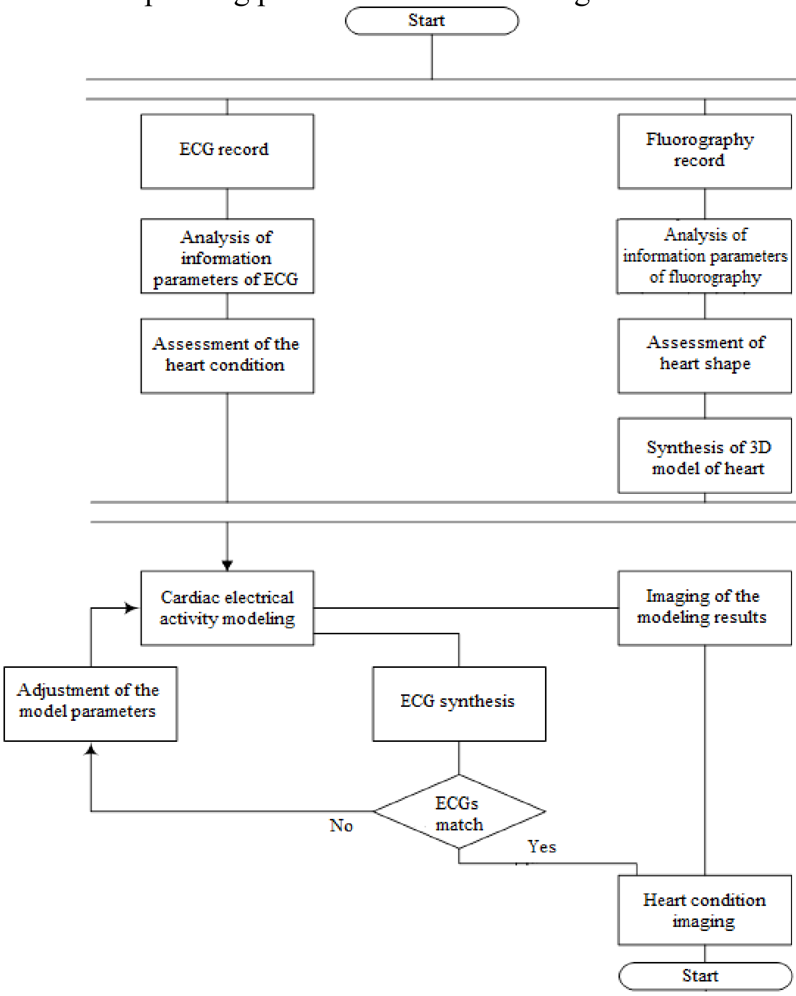

Fig. 2. Algorithm for simulation of heart condition imaging.

The analysis of the algorithm shows that it includes the following stages:

- analysis of cardiographic information;
- modeling of CVS condition;
- imaging of CVS condition.

Graphical imaging of the excitation propagation over the surface of the patient's heart is made on the basis of the modeling results.

References

1. V.A. Baranov, D. K. Avdeeva, P. G. Pen'kov, M. M. Yuzhakov, I. V. Maksimov, M. V. Balahonova, M. G. Grigoriev, Structural approach to inverse problems of computerized diagnostics in cardiology, Modern problems of science and education. 50 (2013) (in Russian)
2. Information on http://www.who.int/mediacentre/factsheets/fs317/en/
3. Information on http://www.medicus.ru/fphysician/patient/bolezni-kotorye-ubivayut-34765.phtml
4. Bor Kavcic, Electrodynamics of human heart, Seminar 1b-1. year, II. cycle program, University of Ljubljana Faculty of Mathematics and Physics, 2013
5. Information on http://en.wikipedia.org/wiki/Alexander_Muirhead
6. Yu. E. Yel'kin, The simplest models of excitable media, Mathematical cell (in Russian)