Computer diagnostic of cardiovascular system development experience and prospects

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Abstract **- The paper addresses a number of problems solved in the design of computer systems for functional diagnostics, in particular - the synthesis and restoration of electrocardiographic leads, fetal electrocardiogram separation and analysis during abdominal cardiography, the development of telemedicine and personal diagnostic devices.**

Keywords **- Functional diagnosis, electrocardiography, leads transformation, fetal ECG, KhAI-Medica.**

INTRODUCTION

Scientific and Technical Center KhAI-MEDICA at the National Aerospace University named by N.E. Zhukovsky "KhAI" has years of experience in designing and manufacturing computer systems for cardiovascular diagnostics – PC electrocardiography (ECG) systems, ECG stress-test systems, ECG and blood pressure (BP) Holter monitors, small-sized electrocardiographs based on handheld computers. In this paper we discuss some of the scientific and technical solutions used in the developments of KhAI-Medica, which, in our opinion, may be interesting both for the developers of medical diagnostic systems, and for their users, as well as prospects for the development of computer diagnostic systems in general.

TRANSFORMATION OF ELECTROCARDIOGRAPHIC LEADS

The problem of ECG leads transformation has many clinical applications. Its solution allows the use a smaller number of electrodes at bedside and Holter ECG monitoring, where is desirable to have a large number of leads, but in practice this creates a serious inconvenience for the patient and medical staff. Another application is the task of reconstruction of missing or distorted by artifacts leads on the base of ECG signals recorded with high quality.

Two algorithms of ECG leads transformation – linear and time-dependent nonlinear, based on maximum likelihood method are presented in this paper. The linear procedure ECG transformation formally described as follows:

$$S_k = \vec{C}^T \cdot \vec{U}_k , \qquad (2.1)$$

where the transformation of original system of ECG leads $\vec{U}_k$ in one of the interesting for us ECG lead S_k is considered, $\vec{C}$ - vector of transformation coefficient. The problem of leads transformation is simplified to the problem of determining the transformation coefficients.

But model of the electrical activity of the heart in the form of a fixed dipole, is quite simplistic. It suggests that the resultant dipole moment does not change its position in space configuration of the high conducting blood supply. We introduce into the transformation model dynamic transformation coefficients $\vec{G}$, witch depend on the phase of the cardiac cycle $\theta_k \in (-\pi;\pi)$. Nonlinear transformation of the recorded leads $\vec{U}_k$ to unknown leads S_k in this case will look like:

$$S_k = \vec{G}(\theta_k)^T \cdot \vec{U}_k , \qquad (2.2)$$

USE THE BLIND SOURCE SEPARATION (BSS) TECHNOLOGY FOR BIOMEDICAL SIGNALS PROCESSING

Traditional methods of temporal, spectral or spatial-temporal signal processing can be used to extract individual signals from their mixtures only if there is any a priori information about their temporal characteristics, spectral composition, or about the law of mixing. If there is no such information the BSS problem arises. Its solving is based on the difference in statistical characteristics and the statistical independence of separated signals.

There are a lot of problems in computer processing of biomedical signals, where BSS methods may be applied. One of them is the *problem of fetal electrocardiogram (fECG) extraction* from a mixture of ECG signals recorded on the surface of the mother's abdomen during pregnancy. KhAI-Medica have developed a hardware and associated software to monitor non-invasively the electrocardiogram of both fetus and mother during pregnancy which have advantages over Doppler units. Using our technology based on BSS, the fetal heart signal is separated from the maternal signal and other background noise to allow abnormalities to be identified.

ASSESSMENT OF THE AUTONOMIC NERVOUS SYSTEM

One of the areas of functional diagnostic in which KhAI Medica actively works is the development of theoretical basics, equipment and software for assessment of the Autonomic Nervous System on the base of HRV analysis. This developments was implemented in CardioLab software.

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