Chapter 6
Mobile Heart Monitoring System Prototype

Andrey Kuzmin
Penza State University, Russia

Maxim Safronov
Penza State University, Russia

Oleg Bodin
Penza State University, Russia

Victor Baranov
Penza State University, Russia

ABSTRACT

This chapter describes a design of prototype of mobile heart monitoring system based on the Texas Instruments ADS1298R ECG front end and NRF52832 wireless data transmission chip. The described design and technical details allow developing a new mobile heart monitoring system consisting of ECG recording device, mobile computer (smartphone or tablet). The algorithm for ECG recovery using a reverse filter, whose parameters are determined by means of bioimpedance measurement, is described. The new algorithm of J-point detection is described and examined on the test ECG database. The detection rate is from 88% to 93%. It will allow mobile monitoring system to inform the user about any signs of dangerous heart condition in ECG. The chapter also describes experimental results of wireless protocol bandwidth and contact break detection. The results confirm the efficiency of the proposed technical solutions to mobile heart monitoring for wide range of applications from sports and fitness to monitoring for medical reasons.

DOI: 10.4018/978-1-7998-1974-5.ch006

INTRODUCTION

Nowadays heart disease is an important medical and social problem, the leading reason of human death and physical dysfunction. Modern trends in the heart diagnostics are mobility, wearable devices, ease of use and user-friendly interface.

Currently, portable systems for disease diagnosis and monitoring of human functional state are becoming more common. The market is growing due to increasing demand for information technologies in medicine and the policy of many countries of strengthening the health of their population.

Wearable devices of control and diagnostics of cardiovascular system are the leaders among popular medical devices. "This technology for improving public awareness of health metrics and for the early diagnosis of cardiac symptoms is quite promising" (Bruining, Caiani, Chronaki, Guzik, & van der Velde, 2014, p. 12). Modern technologies allow to design and develop a miniature wearable device for recording of functional state parameters of the person. For their work it is necessary to improve the classical tools and the algorithms for registration and processing of ECG, because work in free movement conditions is characterized by high noise level and smaller number of measurement channels, therefore it requires more energy efficiency.

One of the unsolved problems of modern health care is the risk of sudden cardiac death. This risk affects both the elderly people with known heart disease, and young people who have no idea about their health problems. To reduce the risk of sudden cardiac death it is necessary to improve portable systems recording and processing of ECG, both in hardware and software by improving the methods and means of processing, applying them in free movement conditions. Portable computing devices, such as smartphones or tablets, could increase the effectiveness of heart monitoring (Reyss & Balandin, 2010). The fundamentals of proposed solutions are given in (Kuzmin, Safronov, Bodin, Petrovsky, & Sergeenkov, 2016a) and (Safronov, Kuzmin, Bodin, Baranov, Trofimov, & Tychkov, 2019).

The improvement of portable systems for ECG monitoring is an actual scientific task. This task is complex and it involves hardware engineering, software development, algorithms, experimental studies etc. Two basic aspects that are chosen for current research are:

- Bioimpedance measurement as the ability to restore a real ECG signal in ECG monitoring;
- Cardiac cycle analysis – the ability to detect dangerous heart conditions autonomously using mobile software.

STATE OF THE ART

A lot of modern solutions for mobile heart monitoring could be used under free movement conditions. Some of them are described below.

AliveCor's Kardia Mobile is a modern device used to measure the heart rate and cardiac rhythm (AliveCor, 2016). It is used for recording, storing and transmitting data. The device connects to any portable computer with iOS or Android. It is automatically turned on and connected with AliveCor's application via wireless connection. It informs the user with valuable information of the heart rate that could be used for the early detection of arrhythmia.