Chapter 11
Photoplethysmographic Sensors in Automatized Diagnosis of the Cardiovascular System: New Guidelines in Computer-Based Medical Diagnostics

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ABSTRACT

The implementation of photoplethysmographic sensors in the data capture and data storage to analyze the cardiovascular condition of the patient is a new direction in automatized diagnosis of the cardiovascular system. This chapter contains a description of the use of photoplethysmographic sensors in a computerized patient cardiac monitoring system. The system consists of a portable device for collection of patient’s cardiac data by applying photoplethysmographic method and software for mathematical analysis. An important diagnostic parameter that can be determined by the photoplethysmographic signal is the heart rate variability. The current application of the photoplethysmographic sensors in portable automatized system is of particular importance because the results of cardiac data analysis with these methods can provide not only detailed information about the cardiovascular status of the patients but also provide the opportunity to generate new knowledge about the diagnosis, and the prevention of pathology in cardiovascular diseases.

INTRODUCTION

In recent years, photoplethysmographic sensors have found new applications as sources of information in physiological non-invasive human studies (Allen, 2007). They are constructed as portable photo sensors, measuring the change in the density of the light flow passing through the peripheral organs of the human body - finger, ear and others (Kim & Lee, 2010). Because of these characteristics, photoplethysmographic sensors are increasingly engaging in portable, mobile capture and recording systems for medical research on the human body (Allen, 2007). From the point of view of diagnostic and clinical medicine, one important application is the heart rate variability (HRV) study by capturing and processing the heart rate data of the patient over a prolonged period of time (Buccelletti, Bocci, Gildardi, Fiore, Calcinaro, Fragnoly, Maviglia, & Franceschi, 2012). Such a study of the cardiovascular system is a difficult task because of the need to process a large amount of information. For example, in the daytime (24 hours) the heart makes about 100,000 beats. For the analysis of the HRV in 100,000 registered pulse cycles, a variety of diagnostic mathematical methods are developed that are applied in modern automated systems using low-cost remote diagnostic devices and equipment, easy to use at home, using the latest computerized technologies.

One way to achieve this is to develop customized medical devices that would allow patients to collect their own physiological data and use wireless technologies to pass this information to specialist physicians or to medical centers. Consequently, the most up-to-date devices must be reliable, accurate, fast, safe, and of course inexpensive. This will provide patients with more mobility and reduce their physical and psychological stress by helping to improve the quality of life.

HRV is a useful biomarker that measures characteristics of the autonomic nervous system (ANS), which regulates the internal organs, including the heart. This parameter is an informative and non-invasive, showing a lot of information regarding the quantification and characterization of ANS (Ernst, 2014). Low parameters of HRV indicate poor health, not only associated with cardiovascular diseases but also with diseases such as diabetes, oncological diseases, etc. (Mirza & Lakshmi, 2012; Soni, Shukla, Dube, Shukla, Soni, & Soni, 2014). The advantage of this research method (HRV) is its ability to detect minor cardiovascular abnormalities, so its use is particularly effective in assessing the body’s overall functional abilities as well as early disease abnormalities which, in the absence of the necessary preventive measures, can lead to serious illnesses.

This chapter presents the application of the photoplethysmographic sensors in portable automatized systems for cardiovascular diagnostics. Such systems consist of:

1. Sensors and computerized devices to capture information about the patient’s current health condition by applying a photoplethysmographic method, suitable for prolonged study, with advantage of providing better comfort to the observed individuals than conventional (electrocardiographic) methods. The use of sensory devices improves the ability to monitor and control risk groups of patients suffering from cardiovascular disease. They are easy to operate throughout the day without the need for specialized medical staff.

2. Software for the analysis of registered photoplethysmographic signals using linear (time and frequency analysis) and non-linear mathematical methods. The graphical capabilities of the attached software are a helpful tool for physicians to diagnose the health condition of patients.