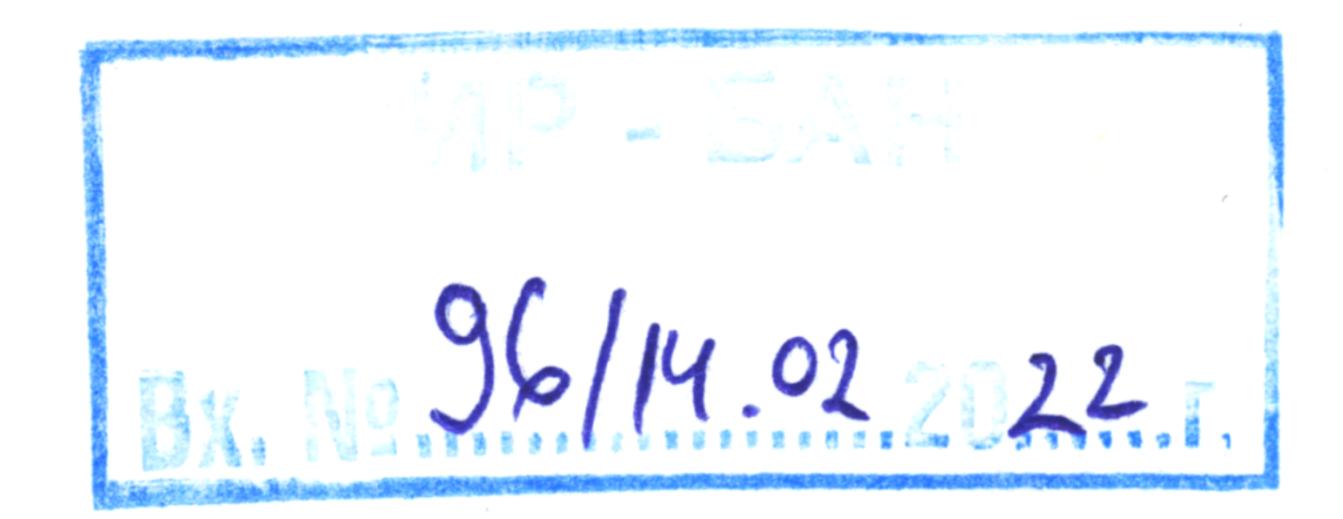
REVIEW



from

Prof. D.Sc. eng. Raicho Todorov Ilarionov, Technical university - Gabrovo

Department of "Computer systems and technologies"

For obtaining the educational and scientific degree "Doctor", Field of higher education: 5. "Technical sciences",

Professional field: 5.2. "Electrotechnics, electronics and automatics",

Scientific specialty: 02.21.01. " Elements and devices of automation and computer technology ".

Author of the dissertation: Eng. Krasimir lordanov
Cheshmedzhiev

Topic of the dissertation: "PORTABLE COMPUTER SYSTEM FOR CARDIAC SIGNALS"

1. Relevance of the problem developed in the dissertation in scientific and scientific-applied terms.

Diseases of the cardiovascular system are one of the leading causes of death worldwide. Recent research shows that cardiovascular disease can be reduced through screening for early detection and prognosis to reduce complications and improve quality of life. Portable medical devices for computer diagnostics of biosignals are designed for autonomous examination of the health status of a wide range of users. Biomedical signals are physical manifestations of physiological processes occurring in the human body that can be measured and presented in a form convenient for processing electronically and thus to create portable devices for diagnosing cardiovascular disease. The heart is known to be a continuous organ that performs about 100,000 heartbeats a day. Mathematical modeling of such a process requires the implementation of significant computational procedures. Any research in the direction of studying the functioning and forecasting the state of the cardiovascular system is a rather complex process and can be considered a topical and important scientific topic.

I believe that the topic of the dissertation is extremely relevant, based on world statistics on cardiovascular disease.

2. Degree of knowledge of the state of the problem and creative evaluation of the literary material.

The PhD student has made a broad and contemporary literature review on the topic of the dissertation. In his literature he cited 128 sources, a large part of them were published after 2015. The manner of presentation, terminology, style, and level of the presented note indicate a good knowledge of the issue. The formulated tasks and the achieved results are a guarantee for an excellent preparation of the author. In the dissertation work a good analysis of the methods and means for obtaining cardiac information, its processing and presentation and in a suitable form for diagnosis. All this speaks of a creative depth and broad knowledge of the topic of the dissertation.

3. Correspondence of the chosen research methodology with the set goal and tasks of the dissertation.

From what is stated in the first chapter, the author's desire for a comprehensive solution to the problem is evident. This determines not only the chosen research methodologies, but also the structuring of the contributing chapters.

I believe that there is a compliance of the chosen research methodology with the goals and objectives of the dissertation. The results of the theoretical research, as well as the logic of this research, determine the reliability of the material on which the doctoral student's contributions are based.

4. General analytical characteristics of the dissertation.

The dissertation is presented in a total volume of 145 pages, including an introduction, four chapters, a conclusion, scientific contributions, a list of references, a list of publications on the topic of the dissertation and two appendices.

The first chapter is presented in a volume of 29 pages. It presents methods for obtaining cardiac signals and extracting information about the activity of the cardiovascular system. A comparative analysis between existing approaches and methods for processing heart signals and software is proposed. Conclusions are made to assess the dynamics of the heart and the functioning of the cardiovascular system and a conclusion about the health of the human body as a whole. The main goal and the related tasks of the dissertation are clearly formulated.

The second chapter has a volume of 24 pages. It proposes a model of a portable photoplethysmographic device for recording cardiac signals. The author has presented a detailed block structure with all components described in detail. He paid special attention to the choice of microcontroller, defining the requirements for it and proposing a comparison table. He conducted testing for possible options. Based on an assessment, he made a choice. He proposed a solution for analog communication using a richer set of sensors and took care of filtering out parasitic signals. It provides the ability to record data from heart

rate sensors on an external removable memory card (micro SD), display real astronomical time during the study, wireless communication to other environments and an extension to upgrade the system. A protocol for exchange with a computer or other computing devices has been developed.

The third chapter has a volume of 26 pages. This chapter presents the algorithmization of the presented hardware model. Functionalities of the software program for analysis of heart rate variability are described. A block diagram of the software approach is proposed. An algorithm for pre-processing of ECG signals and an algorithm for pre-processing of PPG (photoplethysmographic) signals are structured. In this chapter, the dissertation describes two methods for analyzing heart rate variability. The first offers linear analysis in the time and frequency domain, and the second one - nonlinear analysis. These two methods are supported by software implementation.

The fourth chapter is experimental results and application of the system for registration and analysis of cardiac data. Here the doctoral student offers an assessment of the accuracy of the device for recording PPG signals and statistical analysis and an assessment of the accuracy of the created software for HRV analysis. Motivates the application of the developed portable device for automation of the process for continuous monitoring of the indicators reflecting the physical condition of the body of patients with cardiovascular diseases, such as: electrocardiogram, blood pressure, pulse, respiration, temperature, etc. Solving this problem will significantly improve the situation related to the diagnosis of cardiovascular disease, as well as continuous monitoring of patients in the process of their treatment.

The separate main conclusions in the dissertation work summarize the formulated conclusions in the separate chapters and list the scientific contributions of the development.

The volume and structure of the dissertation work meet the requirements.

5. Evaluation of the contributions in the dissertation work and their significance.

The contributions formulated by the author of the dissertation are as follows:

Contributions of a scientific nature have not been proposed.

Contributions of scientific and applied nature:

- 1. A new portable device for recording cardiac signals has been created, based on a photoplethysmographic method with the possibility of positioning it on different areas of the human body (fingers and ear).
- 2. New algorithms for pre-processing of registered ECG and PPG signals have been developed, including: conversion of the analog signal into digital, low-frequency and high-frequency filtering, determination of RR (PP) interval series.
- 3. A new communication protocol has been created for two-way communication between the portable photoplethysmography device and a personal computer.

Contributions of an applied nature:

- 1. The algorithms for pre-processing of the registered ECG and PPG signals are programmatically implemented.
- 2. Software for analysis of heart rate variability using linear and nonlinear mathematical methods has been developed, which is built on a modular principle and allows to add additional functionality if necessary.
- 3. To validate the created new portable PPG device, experimental studies have been performed on its operation by comparing it with a second reference method electrocardiogram.
- 4. An experimental wireless sensor network was created for remote monitoring of patients with cardiovascular diseases, using wireless sensors to record data: RR and PP interval series, temperature, number of steps, SPO₂.

6. Assessment of the degree of personal participation of the doctoral student in the contributions.

I accept the claims formulated in this way for scientific-applied and applied contributions to the considered scientific field. It should be noted that the author has very carefully defined and balanced the scientific-applied with applied contributions. Each of them is clearly stated in the note. There may be room for one or two more contributions, given the relevance and novelty of the issues at stake.

The detailed description, as well as the presentation and analysis of the results show that the development is a personal work of the author.

7. Evaluation of dissertation publications.

The dissertation is defended with 8 publications, as follows:

A 7 of them are in English language;

One of them is independent;

Two publications have an IF (3.706, 2.679);

Two publications have a SJR (0.2, 0.18);

One publication is indexed in WoS.

One is published in IEEE;

The two others have been published in international scientific editions.

The reviewer knows facts about 10 citations. The publications describe various aspects of the dissertation and I believe that they have given the scientific community the opportunity to get acquainted with it. They cover the topic of the dissertation.

8. Is there a direct economic effect of the results of the dissertation.

The author has not deposited implementations of scientific achievements in practice. No direct economic effect is indicated.

9. Recommendations for future use of contributions.

The author must find a way to protect the intellectual property of the device, to implement and manufacture it and to find practical application in medical circles.

10. Assessment of the compliance of the abstract with the requirements for its preparation, as well as its adequacy to reflect the main points and scientific contributions of the dissertation.

The abstract of the dissertation is 47 pages long and follows the structure of the dissertation as a structure. It is well designed. It sets out the main elements of the research and the results obtained. Adequately reflects the content of the dissertation and the results obtained. Evaluation of the compliance of the abstract with the requirements for its preparation, as well as its adequacy to reflect the main principles and scientific contributions of the dissertation.

11. Critical notes on the dissertation.

The topic is extremely relevant, perspective and quite difficult. At first glance, it can be considered as a solution to an engineering problem. Undoubtedly, the proposed model and implementation is a combination of high value and interesting scientific solutions with good practical engineering training.

12. Reasons and clearly formulated conclusion.

I do not know the author personally. My conclusion is based on the materials provided to me.

The dissertation meets the requirements for relevance, required volume, structure and publications. The author has shown knowledge of the researched problem and skills for its solution.

Law on the Development of Academic Staff in the Republic of Bulgaria. The achieved results give me grounds to propose to the esteemed jury to award the educational and scientific degree "Doctor" to Eng. Krasimir Yordanov Chesmedzhiev in the field of higher education. – 5. Technical sciences, Professional field – 5.2. "Electrotechnics, electronics and automatics", Scientific specialty: 02.21.01. "Elements and devices of automation and computer technology."

27.01.2022

Reviewer.

(Prof. D.Sc. Raicho Ilarionov)