

on the acquisition of the educational and scientific degree "Doctor"

Field of higher education: 5. Technical sciences, Professional direction: 5.2 Electrical, electronics and automation, Scientific specialty: 02.21.01. Elements and devices of automation and computing

Author of the dissertation work: Eng. Krassimir Yordanov Cheshmedzhiev, Institute of Robotics at BAS (IR-BAS)

Member of a scientific jury: Prof. Dr. Eng. Galina Todorova Bogdanova – Todorova, IMI at BAS Theme of the dissertation work: PORTABLE COMPUTER SYSTEM FOR CARDIAC SIGNALS

1. Topicality of the problem developed in the dissertation

The diseases of the vascular system (one of the leading causes of death worldwide) and computer diagnostics of bio-signals are extremely up-to-date and promising scientific research topics. From recent research related to portable medical devices for autonomous health testing and computer science diagnosis of patients makes it clear that many more open questions remain and there are a few difficulties in solving them. The study of the work of the heart, mathematical modeling and the prediction of complex processes related to the functioning of this organ with continuous action require significant in volume and complexity computational procedures.

The theme of the dissertation work is significant because the studies and corresponding results achieved in the direction of timely detection of cardiac diseases and prediction of the state of the cardiovascular system are a prerequisite for reducing complications and improving the quality of life in patients.

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

The dissertation cited 128 references. Most of the references are in English. A thorough literary study of contemporary sources on the subject is made (most of them are published in the last 6-7 years). The extensive research on the subject, the precisely used scientific apparatus, the creative analysis and adaptation of the best contemporary achievements show the good level of competence and in-depth knowledge of the theme of the PhD student.

3. General characteristics of the dissertation work

The dissertation work consists of 145 pages (introduction, four chapters, conclusion, contributions, list of used references /128 sources/, list of publications on the topic of thesis of the dissertation /8/ and two applications). The structure and volume of work meet the requirements. A good indicator of the author's knowledge of the problems are the logical and consistent way of research, the good style, and the level of presentation of the problems.

- 3.1 The author examines the methods of obtaining cardiac signals and extracting information about the activity of the cardiovascular system. Performs comparative analysis between existing approaches and methods of processing heart signals and software, conclusions to assess the dynamics of the work of the heart and the functioning of the cardiovascular system. The PhD student defines the main purpose and tasks of the dissertation work.
- 3.2 There are created: model of portable photoplettismographic device for recording cardiac signals; block structure with all components described; selection of microcontroller (requirements, comparative table; testing and evaluation of options); a solution for analog communication to use a set of sensors and filter parasitic signals. Additional options are envisaged in the development: recording an external removable memory card;

displaying real astronomical time; wireless communication to other environments; upgrading the system; and exchanging protocol with a computer or other computing devices.

- 3.3 **Algorithms** related to the presented hardware model (algorithm for pre-processing ECG signals and algorithm for pre-processing of PPG /photoplettesmographic/ signals) have been developed; the functionality of the software system for analyzing the variability of heart rate; block circuit; two methods for analyzing the variability of heart rate (by line analysis in the time and frequency area and by non-line analysis) and their software implementation.
- 3.4 Experimental results and application of the system for recording and analyzing cardiac data are presented; assessment of the accuracy of the device for recording PPG signals, statistical analysis, and assessment of the accuracy of the created software for analysis of the HRV. The application of the developed portable device for automating the process for continuous monitoring of the indicators of the physical condition of the body of patients with cardiology diseases (electrocardiogram, blood pressure, pulse, breathing, temperature, etc.) provides a complex solution to the problems related to the diagnosis and continuous monitoring of patients in the process of their treatment.
- 3.5 The **main conclusions** are made, which summarize the decisions and conclusions of the individual chapters and the **contributions** of the dissertation work.

In the work there is a compliance of the chosen methodology of research with the assigned purpose and tasks of the dissertation work. The methodology created and the application software developed provides a complete solution to the problems (a comprehensive analysis of the methods and means of obtaining cardiology information, its processing and presentation is made and in an appropriate form for diagnosis; on the basis of critical analysis, the main purpose and tasks are formulated; the methodology, application software are adequately developed and the results in the contribution chapters are structured; experiments and assessments to demonstrate the proposed methodology). The consistency and logic of the research proves the creative depth of the PhD student and the credibility of the conclusions and contributions made.

4. Evaluation of contributions to the dissertation work and their importance

In the dissertation work are set out the following contributions of a scientifically applied nature:

- New portable device for recording cardiac signals based on photoplettismographic method with the possibility of positioning it on different parts of the human body (fingers of the hand and ear).
- New algorithms for pre-processing registered ECG and PPG signals, including conversion of analog signal into digital, low frequency and high frequency filtering, determination of RR (PP) interval series.
- New communication protocol for making a two-way connection between the portable photoplethysmography device and a personal computer.

The following contributions of an applied nature are formulated:

- Algorithms (software) for pre-processing of registered ECG and PPG signals.
- Software for analyzing the variability of heart rate using linear and non-linear mathematical methods, which is built on a modular principle and allows additional functionalities to be added if necessary.
- Experimental studies to validate the work of the created new portable PPG device by comparison with a second reference method electrocardiogram.
- Experimental wireless sensor network for remote monitoring of patients with cardiovascular disease using wireless sensors to register data: RR and PP interval series, temperature, number of steps, SPO2.

I accept the formulated scientific and applied and applied contributions from the author of the dissertation and their undeniable importance to the scientific field under question. My conclusions about the author's own participation in these contributions are based on my personal observations of the author's work on the dissertation and the results he has achieved over the years, as well as on the precise and competent details of these issues in the dissertation.

5. Publications and citations under the dissertation work

The author has 8 publications in the list of publications on the topic of dissertation. The publications refer to research on the topic of the dissertation and cover the minimum requirements. Two publications have an impact factor: IF 3.706 and IF 2.679. Two publications have SJR (0.2 and 0.18). One publication is indexed in Web of Science and one publication is in the IEEE databases. Two of the articles are in international scientific editions. One of the articles is self-contained. Seven publications are in English, and one is in Bulgarian.

The author has 10 known citations from the publications on the topic of the dissertation.

6. Assessment of the compliance of the abstract with the requirements for its. preparation

The abstract of the dissertation is 47 pages, and it has a good layout, and fully complies with the requirements for its preparation. There is a correlation of the author's abstract of the dissertation and its structure follows that of the dissertation. It briefly describes all parts of the dissertation and adequately reflects the basics parts of the dissertation (the most important studies carried out, the results obtained, the conclusions and the contributions and the corresponding list of publications).

7. Critical notes and recommendations on the dissertation

I have no significant critical remarks to the author. He has shown expertise and knowledge of the research problem, has proposed interesting methods and approaches to solve it. It would be good if the author in the future described all his studies in another format (for example, as a monograph / or a manual, where there should also be a section with even more detailed instructions/ manual for using the created device). This may be useful in future implementation in the practice of these high-value and interesting scientific solutions (for medical and other environments) and thus to achieve an economic effect of the results in the dissertation.

8. Motives and a clearly formulated conclusion

I know the author of our work on scientific projects. My conclusion on his scientific achievements is based in addition to the materials provided on the dissertation and on my good impressions of his work in this field, his competence, the reports and discussions presented at seminars and other scientific forums.

I believe that the dissertation presented meets the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria, its Rules and Regulations of BAS and IR-BAS. The dissertation has an up-to-date and significant theme, a good structure and way of exhibition, a sufficient volume and number of publications with proposed scientific solutions.

The scientific indicators of the PhD student, exceeding the minimum requirements for the acquisition of the educational and scientific degree "Doctor" and the very good, achieved results, give me grounds for a positive assessment. I propose to the scientific jury to award the educational and scientific degree "Doctor" to Eng. Krassimir Yordanov Cheshmedzhgiev in the Field of Higher Education 5. Technical Sciences, Professional direction 5.2. Electrical engineering, Electronics and Automation, Scientific Specialty: 02.21.01. Elements and devices of automation and computing.

05.03.2022	Member of the scientific jury:
	(Prof. Dr. Eng. Galina Bogdanova)