

OPINION

by

Assoc. Prof. PhD Rayna Georgieva – ИИСТ-БАС

of

the dissertation work of **Petar Rumenov Zhivkov**

with the title

**„MODELING THE STATE OF AIR QUALITY BASED
ON HEALTH AND ECONOMIC ASPECTS“,**

presented to acquire the educational and scientific degree „**doctor**“ in the doctoral program
"Informatics", professional area 4.6 "Informatics and computer sciences", field of higher
education 4., „Natural sciences, mathematics and informatics“,

with supervisor Prof. D.Sc. Stefka Stoyanova Fidanova – ИИСТ-БАС

This opinion is prepared according to the order № 276/06.11.2024 of the Director of ИИСТ-БАС issued because of art. 2 par. 2 of the Law on the Development of the Academic Staff in the Republic of Bulgaria (LDASRB) and decision of the Scientific Council of ИИСТ-БАС, described in Protocol №11/30.10.2024, with which I am appointed as a member of the scientific jury, and according to the decision of the first meeting of the scientific jury held on 11.11.2024 (Protocol №1/11.11/2024).

I have received all the necessary documents. The presented documents meet the requirements of LDASRB, the Regulations for its implementation, as well as the Rulebook on the specific conditions in ИИСТ-БАС for the implementation of the law.

1. Relevance of the topic

Petar Zhivkov's dissertation is in the field of information and communication technologies. The subject of the study is the impact of fine particulate matter (PM) on acute diseases in Sofia, as well as the development of prevention methods.

The topic of the dissertation is extremely relevant. In the last decade, there has been increased interest among society and governing bodies at the national or global level in the impact of air pollution on public health or specific aspects of it, especially in large cities. This necessitates the development of models for predicting the level of acute morbidity based on air quality data. Existing studies show links between air pollution and respiratory diseases, cardiovascular diseases, adverse birth outcomes and even mental health problems. However, a comprehensive study of the scale and mechanisms of these links is still necessary in order to form better-reasoned and more effective policies at the state and local levels.

In this context, the results of the dissertation are extremely valuable because, on the one hand, they contain an in-depth analysis of air pollution and acute disease data from two Sofia hospitals and the Emergency medical services in Sofia. On the other hand, they demonstrate the practical benefit of developing and implementing a common scalable software system with a modular structure for collecting and processing data from various stations and IoT (Internet of Things) devices. This system has the ability to both process and calibrate data and generate air pollution maps, and it is suitable for integration into various applications and platforms, for example, a mobile application used by thousands of users per week.

2. Level of the knowledge of the state of the problem

There is no doubt that the author has learned in depth the scientific topic of this multidisciplinary study and is acquainted with the current state of the problem. This is evidenced by the clearly defined goal, the precisely formulated tasks, the presentation of the text of the dissertation, as well as the list of 104 cited sources.

3. Research methodology

The complex approach in the methodology of this study is extremely impressive. On the one hand, standard scientific approaches appropriate for the specific studies have been applied. These include various methods for statistical analysis in order to determine the levels of correlation between air pollution and the number of patients admitted to hospitals or seeking emergency medical care in specific situations, the use of artificial neural networks, as well as the development of information systems, such as an IoT platform for data visualization and optimization of bicycle lanes. In addition, the methodology also includes data collection from two large Sofia hospitals (University Multiprofile Hospital For Active Treatment And Emergency Medicine "N.I. Pirogov" and Acıbadem City Clinic Tokuda Hospital) and from the capital's emergency medical care center, as well as from monitoring stations of the Ministry of Environment and Water, calibration of civil laser sensor stations, for which supervised and unsupervised machine learning models were used, a new approach for aggregation, organization, processing, modeling and exchange of data in the IoT system has been applied. All this shows a wide range of knowledge and skills of the author, a high level of competence of known approaches and an innovative approach in the use of modern information and communication technologies.

4. Dissertation structure and main contributions

The dissertation consists of 119 pages, 12 figures and 16 tables. It includes a list of tables, a list of figures, an introduction, four chapters, a conclusion, including a reference to the contributions, a list of publications on the topic of the dissertation and a declaration of originality of the results, and a bibliography. A total of 108 literary sources are cited, all in English, including the author's publications. The dissertation presents 4 main scientific-applied and 4 main applied contributions, which are described below.

The **introduction** comments on the relevance of the present study and the author's motivation to approach the solution of the specific problem. The goals and objectives of the dissertation are formulated. The research methodology and the structure of the dissertation are described.

The **second chapter** provides an analytical overview of the impact of the PM on a spectrum of acute diseases in Sofia. Data from two large Sofia hospitals (University Multiprofile Hospital For Active Treatment And Emergency Medicine "N.I. Pirogov" and Acıbadem City Clinic Tokuda Hospital) and cases in the capital's emergency medical care center were examined. The dynamics of hospitalizations on days of air pollution below and above the World Health Organization (WHO) health standards were studied. The need to use civilian laser stations to supplement the representative data from the official measuring stations of the Ministry of Environment and Water is motivated.

The results of this chapter are published in one of the author's publications on the dissertation.

In the **third chapter**, a two-step method with artificial neural networks and anomaly detection for automatic calibration of data from civilian laser stations for measuring PM was presented. Five machine learning models were used to calibrate the data and were compared in terms of the accuracy of their results. Official measuring stations of the Ministry of Environment and Water were used as reference values. The models also include the influence of humidity, atmospheric pressure and temperature. **This innovative method provides more reliable and accurate measurements than laser sensors and has the potential to be used in a wide range of sensor applications. And the developed software allows air quality control organizations to use more reliable real-time data for decision-making and pollution management.**

The results of this chapter are published in one of the author's publications on the dissertation.

In the **fourth chapter**, a model to select the most suitable bicycle route with respect to minimal PM inhalation by the cyclist is described. For this purpose, a modified algorithm for finding the shortest paths is used. An experimental implementation and validation of the developed methodology through real field tests have been made. The results of PM pollution and inhalation of two routes - the one proposed by the software and a route that follows bike lanes - have been examined and compared. **The developed software can be useful for individual cyclists and urban infrastructures that encourage cycling.**

The results of this chapter are published in one of the author's publications on the dissertation.

The **fifth chapter** describes the process of developing an IoT platform architecture, which uses a new approach to aggregation, organization, intelligent processing and exchange of data in the IoT system. The platform visualizes geographical maps, supplementing them with measurements from air quality sensors and current traffic data. **This software supports automation and facilitates the integration of data from various sources, improving the efficiency and accuracy of air quality monitoring.**

The results of this chapter are published in one of the author's publications on the dissertation.

The **sixth chapter** contains the conclusion, which summarizes the results obtained in the dissertation work and indicates the scientific-applied and applied contributions. Future directions for research and development are determined. Strategies are proposed to address the challenges associated with air pollution and its impact on human health.

The achievements in the dissertation work correspond to the set goal and the formulated tasks for its achievement. I accept the contributions formulated by the author with respect to the research conducted and the results obtained. I believe that they contribute to enriching the existing knowledge on the impact of PM, to the development and improvement of air pollution measurement systems and related technologies, to the development of effective policies and to increasing public awareness, which is expected to lead to improved air quality management and better protection of human health.

5. Assessment of the fulfillment of the minimum requirements according to the regulations

From the presented report on the fulfillment of the minimum requirements of IICT-BAS for the educational and scientific degree "doctor" in the professional field 4.6. „*Informatics and Computer Science*“ it is clear that the minimum requirements of 80 points are fully met and slightly exceeded (82 points). The results of the dissertation work have been published in 4 publications in English, of which 3 with impact rank, referenced in the global referencing and indexing system and also published in international publications and conference volumes. One of the publications is independent, and three have 1 co-author, and Petar Zhivkov is the first co-author of all three. The papers were published in the period 2020-2024. The results were reported at the following international conferences: FedCSIS 2021, FedCSIS 2022, held in the city of Sofia with over 200 participants from all continents, Conference on Environmental Protection and Disaster Risks 2020 - with over 80 participants from Europe.

6. Abstract

The abstract has been prepared in accordance with the requirements of the relevant regulations. In general, the abstract correctly reflects the content and main contributions of the dissertation work. It is 55 pages in Bulgarian and 51 pages in English.

7. Critical notes

I have no significant critical remarks. I have noticed some stylistic inaccuracies and typos in the dissertation, which do not diminish the significance of the achieved results.

8. Personal impressions

I have known Petar Zhivkov since he was a PhD student in the section. I am acquainted with his scientific work, as he has presented his results at seminars of the section, and my impressions are entirely positive. Petar was highly motivated to carry out the research on the topic of his dissertation. He knows how to attract the attention of the audience and present the essence of the results obtained. On the other hand, at the seminars I noticed that he readily accepts recommendations for improvements or expansion of the research, which shows his desire for development.

Petar has managed to produce one independent publication, which is another confirmation that his personal contribution to achieving the results in the dissertation is significant and that he is already an established researcher.

9. Conclusion

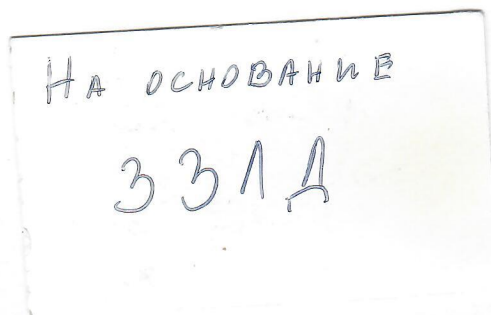
The topic of the dissertation is relevant. Significant scientific and applied results have been obtained, which represent an original contribution to the field of informatics and a clearly expressed applied contribution to the prevention of human health and more effective management of air quality. A comprehensive study with development prospects is presented. There is no doubt about the author's personal participation in the presented dissertation work and the results obtained.

The dissertation fully meets all the requirements of the LDASRB, the Regulations for its implementation, as well as the Rulebook on the specific conditions in ICT-BAS.

All this gives me reason to **confidently give my positive assessment** of the conducted research and to recommend to the scientific jury to **award the educational and scientific degree of „doctor“** to **Petar Rumenov Zhivkov** in the doctoral program „*Informatics*“, in the professional field 4.6 „*Informatics and Computer Sciences*“, in the field of higher education 4. „*Natural Sciences, Mathematics and Informatics*“.

05.02.2025 г.

Sofia



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