OPINION

on a dissertation for acquiring of educational and scientific degree "doctor" in higher education area 5. Technical Sciences, professional field 5.2. Electrical Engineering, Electronics and Automation in doctoral program "Automated information processing and control systems" at the Institute of Information and Communication Technologies of the Bulgarian Academy of Sciences

1. Assessment for compliance with the minimum national requirements.

The opinion is prepared by professor eng. Marin Simeonov Marinov, Ph.D., Faculty of "Aviation" of the "Georgi Benkovski" Bulgarian Air Force Academy, Dolna Mitropolia, in his capacity as a member of the scientific jury for the evaluation of a dissertation on topic "Cyber-physical systems for intelligent management of animal husbandry complexes" with author Eng. Kristiyan Simeonov Dimitrov. The scientific jury was appointed with order № 231/01.10.2025 of the Director of the Institute of Information and Communication Technologies of the Bulgarian Academy of Sciences (IICT-BAS).

In my opinion, the dissertation submitted to me meets the requirements of art. 6, para 2 of the Act on the development of the academic staff in the Republic of Bulgaria (ADASRB) and art. 27 of the the Regulations on its implementation (RIADASRB). This gives me reason to assume that the minimum required 50 points under the group of indicators A for the educational and scientific degree "doctor" defined in RIADASRB.

In the provided to me reference for the compliance with the minimum requirements of IICT for acquiring of educational and scientific degree "doctor", it is correctly reflected in which indicator from the group of indicators Г do the dissertation publications fall. For three of the publications under indicator 7, 16.66 points per publication are indicated, but they should be 13.33 points each. Since the total sum of points in group Г corresponds to the actual points, I assume that this discrepancy is due to a technical error in preparing the report. This gives me the reason to recognize 66.7 points under group of indicators Г, which exceeds the minimum requirements for educational and scientific degree "doctor".

The submitted to me summary of dissertation is 48 pages long, meets the requirements for its formatting and presents the main results obtained in the dissertation. In my opinion, it is not necessary to include a list of references in the abstract and cite them in it, since this is done in the dissertation.

The reports of the automated system of the Bulgarian Academy of Sciences for checking for similarity with other publications show that both coefficients of the system are below 1%, which is a sign of a low level of similarity. I am not aware of any written notification of plagiarism or unreliability of the scientific data presented in the dissertation within the meaning of art. 4, para. 11 of the ADASRB.

In accordance with art. 2, para. 1 of RIADASRB, I accept the dissertation and the publications provided to me for assessment.

2. Structure and content of the dissertation.

The dissertation is 176 pages long and consists of Introduction, 7 chapters, Conclusion, Contributions, Reference list, Declaration of originality, List of dissertation publications. There are 92 figures and 18 tables in the dissertation.

The list of bibliographical sources includes 167 titles in Bulgarian and English, including sources from Internet sites.

The list of dissertation publications at the end of the dissertation contents 5 publications.

3. Actuality of the problem regarded in the dissertation.

Microclimate control in livestock farms and in aquaponic fish farming systems is becoming increasingly important. On the one hand, better control achieves energy efficiency, increased productivity and sustainability. On the other hand, inappropriate conditions can lead to delayed growth, reduced meat, milk, and egg production, increased morbidity and mortality. The production of meat, fish, milk, etc. is an integral part of the food security of any country, which is a component of the country's national security. With increasing uncertainty on a global and regional scale, the issues of providing national economy with resources, including food products, are increasingly relevant. This makes the problems considered in the dissertation relevant, not only from the point of view of implementing modern digital control systems, but also of increasing the country's food security.

Microclimate is a set of parameters such as temperature, humidity, air velocity, illumination, concentration of harmful gases, etc. which have a direct and indirect impact on the health, productivity and well-being of animals. This sets strict and diverse requirements on the systems for the microclimate control. Undoubtedly, the goal of the dissertation work to develop a cyber-physical system for microclimate control in animal husbandry complexes and for environmental control in fish farming is relevant and adequately formulated. This is confirmed by the fact that there are still no such systems developed that are widely applicable and adopted by producers as a standard in animal and fish farming.

In the dissertation, microclimate control systems for various types of cyber-physical systems have been developed. The developed systems have a high level of automation and can be reconfigured during their operation. This is in line with new trends in reducing human involvement in repetitive processes.

The developed graphical user interfaces allow the information from the system to be presented in different ways to the users, depending on their preferences. In addition, one of the developed graphical user interfaces can be used on different devices, including mobile devices, which is demonstrated in the dissertation.

What has been stated in this point gives me reason to conclude that the topic and the research in the dissertation are relevant.

4. Degree of knowledge of the problem state.

In the first chapter, based on a number of publications, an analysis is made of how the environment and microclimate affect the animals being raised. The main conclusion from the analysis is that the implementation of monitoring and control of

certain environmental .parameters is of utmost importance for the welfare of the animals. The analysis has proven that environmental control helps both to increase productivity and to improve the health of the animals. The microclimate parameters that must be monitored and controlled are determined, as well as those whose control would lead to an increase in the efficiency of animal husbandry. The specific features and differences in the parameters that must be controlled in an aquaponic system are also determined.

In the second chapter, a comprehensive review and analysis of the various types of end-user control devices and actuators for microclimate control used in livestock farms was made, and it was established that there is diversity on the market, which allows the construction of various microclimate control systems. An analysis of the sensors offered on the market for measuring the necessary parameters was also made, and it was established that the specialized ones for use in livestock farms are relatively high priced. An analysis of the offered computer systems for microclimate control was made, and it was established that they do not have the possibility of further expansion in the future, and the price of multi-channel systems is too high and is an obstacle to their implementation in small and medium-sized farms. When reviewing the existing systems for environmental control in an aquaponic system, it was established that there are no such systems on the market that offer full control, but systems for monitoring some of the necessary parameters are used, with the remaining parameters being monitored non-automated, most often using litmus strips.

Based on the in-depth review and analysis of numerous publications related to the issues considered in the dissertation, it was concluded that it is necessary to develop environmental control systems that are modular and can be easily upgraded both by expanding the number and type of controlled parameters and by allowing for changes in the control logic. Such systems would be more easily accessible to a wider range of users.

With what is presented in the first two chapters, the PhD student demonstrates extensive knowledge of not only the technical characteristics and features of environmental control systems, but also of the interrelationship between microclimate control and the productivity of animal farms. He demonstrates very good awareness in the field of computer systems used to control the environment, as well as the features of the methods used in them for its control.

What has been mentioned above shows that the PhD student is well acquainted with various aspects of the regarded in dissertation problems.

5. Correspondence of the goal and tasks with the achieved results in the dissertation.

The dissertation clearly states the goal, subject, and object of the research. Although it is clearly defined what needs to be done to achieve the goal, these steps are not specifically separated as tasks in the dissertation.

In the dissertation work, a multi-stage approach was chosen for the development of cyber-physical systems for intelligent control of animal husbandry complexes. First, a concept was developed that formulated the requirements for the system. Then, criteria were defined and a justified selection of the system elements was made. At the last

stage, an operating system was selected and software was developed to collect information from sensors, control the executive mechanisms and visualize important data on displays for monitoring by an operator

When developing the control algorithms, the specifics of environmental control when raising different animals were taken into account. Possibilities for changing the limits of the monitored parameters, as well as changing the decision-making logic, are provided. Two graphical user interfaces based on different software products have been developed for communication between the operator and the system

The chosen approach in the dissertation allows the developed cyber-physical systems to be flexible during their use, to have a high degree of automation, and to allow for future expansion.

The chosen approach in the dissertation fully corresponds to the set goal. The obtained results show that all the tasks have been fulfilled, which also achieved the goal set in the dissertation.

6. Scientific, applied and practical contributions of the dissertation.

I positively evaluate the contributions in dissertation work, accepting the fully formulated scientific contributions:

- a new method for controlling the microclimate in a poultry farm has been developed, which is based on calculating the temperature felt by the birds;
- a new method for automatically controlling nitrates, nitrites and ammonia in an aquaponic system has been developed, by controlling the amount of food supplied to the automatic feeder.

I believe that the scientific-applied contributions can be better detailed by formulating them as follows:

- a concept has been developed for building a cyber-physical system for intelligent control of animal husbandry complexes;
- an algorithm has been developed for controlling a cyber-physical system for maintaining the microclimate in a cow farm;
- an algorithm has been developed for controlling a cyber-physical system for maintaining the microclimate in a pig farm;
- an algorithm has been developed for fully autonomous control of a cyber-physical system for maintaining the microclimate in a poultry farm, which also takes into account the age of the chickens;
- an algorithm has been developed for controlling a cyber-physical system for maintaining the environment in an aquaponic system, which offers autonomous control of a much wider range of parameters compared to existing similar systems.

I believe that the dissertation contains a greater number of practical contributions than those formulated in it, and I define them as follows:

- cyber-physical systems have been fully developed, that are built from sensors, actuators and control computers;

- results have been obtained from testing the control algorithms in a cow farm and a pig farm through semi-natural experiments, which prove the effective and sustainable operation of the developed systems;
- results have been obtained from implementing the microclimate control system in a poultry farm at Thracian University in Stara Zagora, which has proven a reduction in electricity costs and an improvement in the conditions for the raised birds;
- graphical user interfaces have been developed for visualization of the monitored parameters, which allow for the interactive change of any of the set limits.

7. Evaluation of the dissertation publications.

The 5 publications on the dissertation presented to me are journal articles. Of these, 4 are in publications indexed in the scientific information databases Scopus and Web of Science. One of the articles is in a issue of the Technical University - Sofia.

One of the publications is independent and for are co-authored. Of those co-authored, the PhD student is in the first place in 2 of them and in second place in the rest.

The content of the publications and the journals in which they were published guarantee that the studies in the dissertation and its results have become widely known in Bulgaria and abroad. In addition, the presence of 5 citations of some of these publications indicates interest in the developments in the dissertation.

I believe that the publications correspond to the content of the dissertation and correctly reflect the essential part of the research conducted therein and the results obtained.

8. Opinion, recommendations and remarks.

The dissertation has been developed in the necessary volume and represents a completed scientific and research work. The correct indication of the sources from which some of the figures were used makes a good impression. I have no critical remarks on the substance of the dissertation and the presented results, but I have remarks on the layout and style.

My main remarks on the layout are as follows:

- there is no list of used abbreviations;
- in the list of references, it is recommended to put the titles in Bulgarian first, and the Internet sites at the end of the list;
- when literary sources are cited in the text, it is better to call the list references, not a bibliography;
- the caption under some figures has moved to the next page (for example, the one in figure 2.4).

Regarding style, I have a remark that both active and passive voice are used in the dissertation. In my opinion, the latter way should be used to present scientific research.

These remarks are not of the essence of the work and do not diminish the value of the contributions in the dissertation.

My recommendations to the PhD student are as follows:

- to continue his efforts to implement the research in his dissertation into practice;
- to continue with publication activity in refereed and indexed publications in world-renowned databases of scientific information.

CONCLUSION

I positively assess the work done and the results obtained in the dissertation. The dissertation sufficiently meets the requirements of the ADASRB, the Regulations on its implementation, as well as the Regulations for the specific conditions for acquiring scientific degrees and holding academic positions at the IICT. I propose to the respected Scientific Jury to award the M.Sc. Eng. Kristiyan Simeonov Dimitrov the educational and scientific degree "doctor" in higher education area 5. Technical Sciences, professional field 5.2. Electrical Engineering, Electronics and Automation in doctoral program "Automated information processing and control systems".

26.11.2025 Prepared the opinion

На основание
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