

## REVIEW

by Prof. Dr Vera Angelova Angelova-Dimitrova,  
Institute of Information and Communication Technologies  
at the Bulgarian Academy of Sciences (IICT-BAS)  
of the thesis for awarding the educational and scientific degree PhD,  
in Area 5. Technical Sciences,  
Professional field 5.2 Electrical Engineering, Electronics and Automation,  
PhD program "Automated Systems for Information Processing and Management"  
Author of the PhD thesis: Mag. Eng. **Kristiyan Simeonov Dimitrov**  
PhD thesis title: **"Cyber-physical systems for intelligent management of animal  
breeding complexes"**

With Order No. 231/01.10.2025 of the Director of IICT-BAS, I have been appointed as a member of a scientific jury in connection with the procedure for acquiring the educational and scientific degree PhD in the PhD program "Automated Systems for Information Processing and Management", professional field 5.2 Electrical Engineering, Electronics and Automation, scientific area 5. Technical Sciences by Kristiyan Simeonov Dimitrov with a PhD thesis on "Cyber-Physical Systems for Intelligent Management of Animal Breeding Complexes" with scientific advisor Prof. Dr Nayden Shivarov, IICT-BAS. At the first meeting of the scientific jury, held on October 10, 2025, I was elected as a reviewer.

As a member of the scientific jury, I have received:

- Order No. 231/01.10.2025 of the Director of the Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences
- Order No. 329/10.12.2024 of the Director of the Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences
- Application from Mag. Eng. Kristiyan Simeonov Dimitrov for opening a procedure for acquiring an educational and scientific degree "PhD"
- List of publications on the PhD thesis
- Copy of the publications on the PhD thesis
- Abstract of the PhD thesis in Bulgarian
- Abstract of the PhD thesis in English
- PhD thesis for awarding the degree of PhD
- Declaration of originality
- Reference for the fulfilment of the minimum requirements of the Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences for awarding the educational and scientific degree PhD in area 5. Technical Sciences, professional field 5.2 Electrical Engineering, Electronics and Automation
- Reference for the fulfilment of the minimum national requirements for the educational and scientific degree PhD in area 5. Technical Sciences, professional field 5.2 Electrical Engineering, Electronics and Automation
- Preliminary review of the PhD thesis, prepared by Assoc. Prof. Dr Eng. Stefan Savov Biliderov



## **1. Research Field, Relevance, Goals and Objectives**

The subject of the research in the PhD thesis is the analysis of various parameters of the microclimate in livestock farms and aquaponic systems, the impact that these parameters have directly or indirectly on the respective animal species to improve the health, productivity and welfare of animals, as well as the study of various ways to control these parameters to create reliable environmental control systems while minimizing resources.

In the context of increasing requirements for energy efficiency, sustainability and increased productivity, animal welfare and strict environmental regulations for optimization and efficient use of resources, the topic of building sustainable and precise animal husbandry through digitalization and application of "smart" technologies with the development of widely available microclimate management systems on livestock farms is highly relevant.

The aim of the PhD thesis is to develop a cyber-physical system (CPS) for microclimate management in animal husbandry complexes and for environmental management in fish farming based on openHAB.

To achieve this objective, the following tasks have been formulated:

Task 1: Development of a concept with requirements for the creation of a CPS for intelligent management of animal breeding complexes.

Task 2: Development of a concept for a software system for the management of CPS in an animal breeding complex

Task 3: Research and selection of IoT actuators and sensors with the necessary parameters for use in the Cyber-Physical Management System of an Animal Breeding Complex

Task 4: Develop an intelligent management of CPS for animal husbandry based on openHAB

Task 5: Research and development of graphical interfaces for CPS for intelligent management of animal breeding complexes with the possibility of remote control over the Internet, based on openHAB

## **1. Characteristics and evaluation of the contributions of the PhD thesis**

The PhD thesis of Mag. Eng. Kristiyan Simeonov Dimitrov consists of 178 pages and includes: acknowledgements, introduction, seven chapters, conclusion, contributions, bibliography, publications on the PhD thesis and citations.

Chapters one and two address the primary challenges in modern animal husbandry, along with methods and means for enhancing the microclimate in closed livestock farms and aquaponic systems. The influence of the microclimate on the economic indicators of livestock farms is analysed. The problem area is defined. The parameters whose control would contribute to improve the microclimate in livestock farms are derived: temperature, humidity and speed of air movement, presence of pollutants in the air (harmful gases, particulate matter and microbial contamination), illumination and ambient noise, and in an aquaponic system: water quality, water temperature and pH, dissolved oxygen and carbon dioxide, ammonia, nitrites, nitrates, etc. as well as exposure to direct sunlight. An analysis of the existing methods and means for controlling the environment and microclimate of livestock farms and aquaponic systems is



made, including actuators (ventilation valves, louvres, fans, heating systems, coolers; air pumps, heaters, heat pump installations, automatic feeders), sensors, and computers for microclimate control. Gaps and weaknesses are analysed, and guidelines are formulated for the development of new methods and ways of management in the direction of achieving accessibility of management systems for a broader range of users by developing modular management systems with upgradeability to change both the number and type of managed parameters, and the logic of governance.

In Chapter Three, a concept for implementing the CPS to manage livestock complexes is developed. The main requirements and guidelines for implementing the CPS are outlined, and the sequence of necessary steps is traced. The requirements for all system elements are defined, based on which the specific choice of elements should be made according to the set criteria.

Chapter Four discusses the specific functions of the software needed for the development of the CPS. The operating system is Linux-based OpenHABian, and additional software is used for the creation and reliable operation of the system, including libraries and drivers. The choice is also motivated by the availability of a free and open-source version.

The selection of sensors and additional controllers is made in Chapter Five. After a thorough analysis of the range of sensors available on the market, the choice of appropriate price-oriented sensors with characteristics that meet the compatibility requirements of the interface connecting them and with a range and resolution that correspond to the functions performed in the microclimate management algorithms in livestock farms is justified. Additional controllers have been selected to connect the sensors and end devices to the system server, which offer different connection options.

Chapter Six is devoted to the analysis of the conditions for keeping the most massively kept domestic animals, the development of algorithms for the management of CPS and the conduct of tests and experiments. The CPS for microclimate management in livestock farms, including dairy cows, pigs raised for meat, and broilers raised for meat, as well as for environmental management in an aquaponic system for keeping fish and plants, has been proposed. Tests and experiments have been conducted to effectively select elements – sensors, controllers, and a control computer - that correspond to the technical requirements for system construction. A way of installing, configuring, and setting up the system is proposed. The central nodes and the implementation of the connection between the individual components are shown. CPS tests for microclimate management in a cow farm, in a pig farm and an aquaponic system with a server – a single-board computer Raspberry PI 4 and an open-source OpenHAB server show the effectiveness of the system for small to medium-sized livestock farms. Given the higher workload associated with a greater number of sensors, actuators, and automation equipment for large farms, the PhD student recommends using a more powerful personal computer as a server. During the experiments, the system demonstrated effective maintenance of set carbon dioxide levels, temperature control within preset limits, and illumination levels in the presence of active influencing factors. Emergency response tests, such as high concentrations of harmful chemical gases and levels of fine particulate matter, indicate adequate behaviour of the CPS in the direction of compliance with the set parameters and informing the operator of the presence of an emergency. The developed in the PhD thesis CPS for microclimate management in a poultry



farm shows efficiency and adequate behavior and capabilities for autonomous control with changing the parameters of the environment according to the age of the chickens. Thanks to the introduced method for recording the temperature felt by the birds, the system allows switching to different ventilation modes and responding in an emergency. Recommendations are given for optimal placement of the sensors in the poultry farm. CPS tests for environmental management in an aquaponic system were carried out in laboratory conditions. The proposed CPS for microclimate management in farms for keeping animals in aquaponic systems shows a high level of autonomy with the correct initial setting. A graphical interface allows you to adjust the parameters during the system's operation. Built on a modular principle, cyber-physical systems allow monitoring and control of a wide range of environmental parameters depending on the installed sensors and end control devices.

In Chapter Seven, two types of user graphical interfaces have been developed that can work simultaneously and make it possible to monitor the cyber-physical system from different devices such as a personal computer, tablet and smartphone. Both systems enable full functionality or restrict access to settings based on staff level, and adjust elements according to the specific livestock farm's equipment. The systems are based on Basic UI and HABPanel, respectively. The differences come down to how the sensors visualise values, making it easier for the operator to orient themselves in the situation.

In conclusion, a very synthesised summary of the results obtained is presented. A list of scientific publications on the PhD thesis is presented: four scientific publications in journals that are referenced and indexed in the world-famous databases with scientific information, two of which are reports at the IFAC'22 congress and two are publications in journals. One publication is in a publication of the Technical University of Sofia. All publications are co-authored. A list of five independent citations is presented, with no indication of which publication is cited.

The Bibliography presents 167 literary sources. All are in English. The only cited work by Bulgarian authors is the fourth publication from the publications on the PhD thesis.

## **2. Evaluation of the PhD thesis' contributions**

The PhD student claims the following contributions:

### **Scientific contributions**

- A new method of managing the microclimate in a poultry house has been developed, which is based on the calculation of the temperature felt by the birds, which is different from the temperature in the room and depends on the temperature, humidity and speed of air movement, as well as on the age of the chickens. Publication "Algorithm for Autonomous Management of a Poultry Farm by a Cyber-Physical System" in the journal *Animals* -IMPACT FACTOR - 2.7; CITISCORE – 4.9; SJR – Q1
- A new method has been developed for automatic control of nitrates, nitrites and ammonia in an aquaponic system by controlling the amount of food fed to the automatic feeder. Publication "Concept of a Cyber-Physical System for Control of a Self-Cleaning Aquaponic Unit" in the journal *AgriEngineering* - IMPACT FACTOR - 3.0; CITISCORE – 4.7; SJR – Q1



### **Scientific and applied contributions**

- CPS have been developed for microclimate management in a cow farm, pig farm and poultry farm, built with price-oriented components, and the final price is significantly lower compared to the existing solutions on the market. This makes it easily accessible to small and medium-sized farms for which the initial investment for existing systems is unaffordable.

- The developed CPS for managing the microclimate in a poultry farm allows for fully autonomous control, in which the system independently changes the parameters of the environment according to the age of the chickens and switches between the three ventilation modes without the intervention of personnel. Existing similar systems only offer a transition from minimal to transient ventilation and vice versa. The proposed system also allows for the transition to tunnel ventilation mode, thanks to the introduced method for considering the temperature felt by the birds.

- A CPS has been developed for environmental management in an aquaponic system, which offers autonomous control of a much wider range of parameters compared to existing similar systems, while being able to send recommendations to staff to regulate the number of fish and plants to implement and maintain its balance.

### **Applied contributions**

- The developed CPS for microclimate management in a poultry farm was implemented and tested in a poultry farm together with Trakia University of Stara Zagora, contributing to reducing electricity costs and improving the conditions for birds.

I accept the contributions formulated in the PhD thesis, considering them as scientific-applied and applied contributions.

### **3. Evaluation of the publications of the PhD thesis**

The list of publications on the dissertation includes four co-authored publications, refereed in the world-famous databases Scopus and Web of Science and one independent publication in a publication of the Technical University of Sofia. Two of the publications are papers at an IFAC congress in 2022, and two publications are in reputable international journals of MDPI, falling into quartiles Q1 and Q2 of Web of Science. The number of points received in indicator  $\Gamma 7$  is  $40/3 + 40/3 + 40/3 + 40/6 = 46.667$ . Number of points in indicator  $\Gamma 8$ : 20. In total, the points in indicators  $\Gamma 7$  and  $\Gamma 8$  are 66,667 and significantly exceed the minimum required 30 points. The five independent citations observed are evidence of the publicity of the results and an international assessment of their significance. The list of publications on the PhD thesis includes four publications referenced in the world-famous databases Scopus and Web of Science, and one publication in a publication of the Technical University of Sofia. Two of the publications are papers at an IFAC congress in 2022, and two publications are in reputable international journals of MDPI, falling into quartiles Q1 and Q2 of Web of Science. The five independent citations observed are an evidence of the publicity of the results and an international assessment of their significance.

I am not aware of plagiarism in scientific works being proven by law.

#### 4. Evaluation of the PhD abstract

The PhD abstract consists of 50 pages and contains 87 cited sources. The content and main contributions of the PhD thesis are correctly reflected in the abstract, where the contributions are presented as an Author's reference.

#### 5. Remarks and recommendations

The presentation of the PhD thesis is clear, logically consistent, concise and concrete. After each sentence, the reader encounters exactly the information he expects to receive.

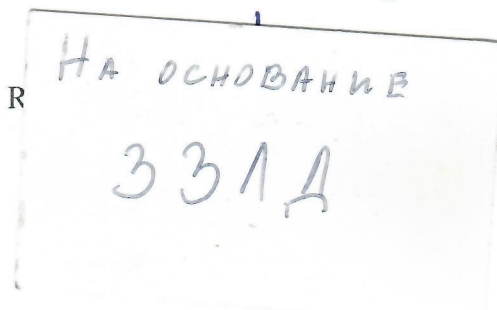
I recommend that, in his future work, the independent scientist Kristiyan Simeonov Dimitrov pay attention when writing the bibliographic data of publications and citations. The literary sources in the Bibliography are presented in different styles. In the list of publications on the PhD thesis, the writing strangely begins with the title of the publication, and not with the authors, as required by the standards. In the list of citations, the cited article is not indicated.

#### 6. Conclusion

The PhD thesis contains results that are scientifically applied and applied in the field of professional field "Electrical Engineering, Electronics and Automation", and most of them are published in specialised journals with SJR rank and renowned international journals with impact factor filling the quartiles Q1 and Q2 of Web of Science. The PhD thesis of Mag. Eng. Kristiyan Simeonov Dimitrov meets the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for the Implementation of the Law on the Implementation of the Law on Academic Achievements, the Regulations on the Conditions and Procedure for Acquiring Scientific Degrees and Occupying Academic Positions at the Bulgarian Academy of Sciences and the Regulations on the Specific Conditions for Acquiring Scientific Degrees and Occupying Academic Positions at IICT-BAS.

After reviewing the presented PhD thesis and related publications, analysing their significance and contributions, **I provide a positive assessment for the awarding of Mag. Eng. Kristiyan Simeonov Dimitrov, the educational and scientific degree "PhD" in the area 5 Technical Sciences, in the professional field 5.2 Electrical Engineering, Electronics and Automation, PhD program "Automated Systems for Information Processing and Management".**

23.10.2025  
Sofia



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