REVIEW

by Associate Professor Emil Hristov Doychev, PhD,
University of Plovdiv "Paisii Hilendarski"
of a dissertation for awarding the educational and scientific degree "Doctor"
Field of higher education: *4. Natural Sciences, Mathematics, and Informatics*,
Professional field: *4.6 Informatics and Computer Science*
Doctoral program: *Informatics*

Author: *Evgeny Vladimirov Valchev*
Topic: IoT Environment for Intelligent Livestock
Scientific supervisors: Prof. Stanimir Nedyalkov Stoyanov, PhD, and
Prof. Todorka Atanasova Glushkova, PhD

1. General Overview of the Submitted Materials

By Order No. РД 22-772 dated March 27, 2025, of the Rector of Paisii Hilendarski Plovdiv University, I was appointed as a member of the academic jury for the defense procedure of the doctoral dissertation entitled **"IoT Environment for Intelligent Livestock"**, for the acquisition of the educational and scientific degree "Doctor" in the field of higher education: 4. Natural Sciences, Mathematics and Informatics, professional field 4.6. Informatics and Computer Science, doctoral program: Informatics.

The author of the dissertation is **Evgeny Vladimirov Valchev**, a full-time PhD student in the Department of Computer Systems under the scientific supervision of Prof. Dr. Stanimir Nedyalkov Stoyanov and Prof. Dr. Todorka Atanasova Glushkova from the Faculty of Mathematics and Informatics at Plovdiv University.

The set of materials submitted to me by Evgeny Vladimirov Valchev in electronic format is in compliance with Article 36(1) of the Law on the Development of the Academic Staff of the University of Plovdiv and includes the following documents:

- Application to the Rector for initiating the doctoral defense procedure;
- Curriculum Vitae in European format;
- A protocol from the preliminary discussion in the department and the opinion of the scientific supervisors regarding readiness for the preliminary discussion;
- Doctoral dissertation;
- Abstract (in Bulgarian and English);

- List of scientific publications related to the dissertation;
- Copies of the scientific publications;
- Declaration of originality and authenticity of the submitted documents;
- Compliance report with the minimum national requirements;
- Official letter certifying participation in projects funded by the Research Fund;
- Supervisors' opinions.

The doctoral student has submitted two scientific publications related to the topic of the dissertation.

2. Brief Biographical Information

Evgeny Valchev obtained a bachelor's degree in business information technologies in 2016 and a master's degree in business informatics with English in 2019, both from the Faculty of Mathematics and Informatics at Paisii Hilendarski Plovdiv University. Since 2021, he has been a full-time doctoral student at the same faculty, conducting research in the fields of artificial intelligence, the Internet of Things (IoT), and cyber-physical networks.

As of 2024, he holds the position of Assistant Professor in the Department of Computer Technologies, where he conducts lab sessions, participates in projects, and contributes to academic seminars. Evgeny Valchev also has many years of professional experience in the IT sector, having worked as a business analyst, project manager, and managing director of a software company.

3. Relevance of the Topic and Justification of the Objectives

The topic of the dissertation is related to the study and development of an IoT-based cyber-physical platform for smart livestock farming, with a specific focus on pasture-based cattle breeding. The choice of this research area is undoubtedly relevant, given the growing global emphasis on sustainable agriculture, the digital transformation of the agri-food sector, and the increasing drive to optimize production processes through the use of new technologies. The subject lies at the intersection of several rapidly evolving domains, including the Internet of Things (IoT), cyber-physical and social systems (CPSS), machine learning, and intelligent resource management.

As highlighted in the introduction and Chapter 1 of the dissertation, there is a clearly recognized need—both globally and nationally—for the development and application of smart systems for automated monitoring and analysis in agriculture. Specifically, in livestock farming, there is increasing demand for solutions that improve efficiency and productivity through real-time observation of animal behaviour, health, and localization. The dissertation's focus on pasture-based cattle farming

is particularly valuable, as this is a relatively underexplored yet ecologically and economically important subdomain, closely linked to the production of organic food under natural conditions.

The main objective of the dissertation, as defined on p. 7 - "Study of the possibilities and development of an IoT-based cyber-physical platform for smart livestock farming" - is well-formulated, realistic, and directly addresses the identified research problem. The specific tasks outlined in the same section reflect clearly defined stages of the scientific work: from reviewing existing solutions, through system architecture development and prototyping, to behavioral modeling and analysis of the monitored animals.

In this context, I consider the choice of research topic, the stated objective, and the defined tasks in the dissertation to be scientifically grounded, fully appropriate, and entirely aligned with current trends in digital technology development and smart agriculture.

4. Knowledge of the Problem

Evgeny Valchev demonstrates a comprehensive and in-depth understanding of the issues addressed in the dissertation. This is evident from the logical structure and clarity of the exposition, as well as from the substantial number of references cited in the bibliography - a total of 111 sources - which reflect the current state of the research topic in scientific literature.

In Chapter 1, the doctoral student systematically reviews the foundational concepts and technologies in the fields of the Internet of Things (IoT), sensor networks, cyber-physical systems (CPS), and cyber-physical-social systems (CPSS). He convincingly argues for their significance in the context of developing smart livestock farming solutions. Special attention is devoted to modern trends in the application of machine learning, particularly deep reinforcement learning (DRL), for behaviour monitoring and analysis of farm animals.

The author also shows a good awareness of the specific challenges in pasture-based cattle farming, including difficult terrain, lack of continuous connectivity, the need for device autonomy, and the complexity of modelling animal behaviour. The dissertation includes a detailed review of the ViPS architecture, developed at the DeLC laboratory of Plovdiv University, which has been adapted to the specific needs of the platform being developed. This reflects not only familiarity with established frameworks, but also the ability to apply and customize them in a targeted and meaningful way.

In addition, the dissertation presents a well-reasoned analysis of various types of sensors, communication technologies, platforms, and approaches for building a complete IoT infrastructure, with an emphasis on practical applicability and technical constraints. The doctoral student's understanding of the problem is further supported by a clear methodology based on real-world case studies,

prototyping, and field testing, confirming his ability to apply theoretical knowledge in practical settings.

All of this provides solid grounds to conclude that Evgeny Valchev possesses a deep and current understanding of the trends, challenges, and methodologies in the domains of smart livestock farming, IoT technologies, and related scientific fields.

5. Research Methodology

The methodology selected for the development of the dissertation is fully aligned with the defined research objective and the specific tasks. The dissertation follows a clear, step-by-step, iterative approach, which includes the following stages: theoretical overview and formulation of a conceptual model, architectural design, prototyping of hardware and software infrastructure, testing, and analysis of the results.

Initially, the doctoral student conducts a comprehensive review of the existing technologies and architectures in the fields of IoT, CPSS, and smart livestock farming. This analysis forms the foundation for developing his own approach, which is based on the adaptation of the ViPS architecture to the specific requirements of pasture-based cattle farming.

In the next stage, the dissertation proposes the architecture of an IoT platform, consisting of a multilayer communication and software infrastructure. It includes a sensor network, sensor devices, server-side and client-side components for collecting, processing, visualizing, and analyzing data. Two successive hardware prototypes of sensor devices have been designed and implemented, along with a Virtual Operations Centre for visual monitoring and data analysis.

A key aspect of the methodology is the validation and testing of the developed components through real-world field experiments conducted in various geographical environments. This allowed the collection of primary data used for analysing animal behaviour and assessing the system's effectiveness.

The dissertation clearly demonstrates the connection between theoretical foundations, technical implementation, and experimental verification of the developed solutions, indicating methodological consistency and a well-structured scientific research process.

I consider the chosen methodology to be appropriate, well-argued, and successfully implemented in the context of the research objective.

6. Structure and Evaluation of the Dissertation

The dissertation by Evgeny Valchev consists of 133 pages, including the bibliography, which contains 111 references in both Bulgarian and English. The structure of the work is logically orga-

nized and includes: introduction, three main chapters, conclusion, list of publications, glossary of terms, and bibliography.

The Introduction clearly defines the research problem, the main objective, and the specific tasks of the dissertation. It also outlines the applied scientific approach. The author places the research within the context of current trends in the digitalization of agriculture and the need for intelligent solutions in sustainable livestock farming.

Chapter 1 presents the motivation behind the study and provides an in-depth review of relevant concepts and technologies such as IoT, sensor networks, cyber-physical and social systems (CPSS), and the applications of artificial intelligence and machine learning. The analysis of technological limitations and implementation challenges in the context of pasture-based livestock farming shows not only theoretical preparation but also awareness of the practical dimensions of the problem.

Chapter 2 focuses on the development of the IoT platform for smart livestock farming. The architectural layers of the system are thoroughly examined, including sensor groups and devices, communication infrastructure, and software components for data collection, processing, and visualization. Descriptions of the developed prototypes, communication protocols, and hardware choices provide evidence of real engineering work and the author's ability to design complex systems.

Chapter 3 presents the results from field experiments with the developed prototypes, the analysis of collected data, and visualizations of animal behaviour in various natural environments. It outlines the functionalities of the Virtual Operations Centre used for monitoring, analysis, and system management. The chapter also includes perspectives for future system development, particularly the integration of advanced AI algorithms for behaviour prediction and optimization.

The Conclusion summarizes the key outcomes of the research.

Overall, the dissertation is written in an academic style, with clear structure, logical progression of ideas, and precise terminology. There is a strong and well-demonstrated connection between theory and practice, and the results presented have real value for the development of intelligent agricultural systems.

7. Contributions and Significance for Science and Practice

The main contributions of the dissertation have a scientific-applied and practical nature and are fully aligned with the research objectives defined in the introduction.

The dissertation defines four major results (p. 116), which can be summarized as follows:

1. **Analysis of existing approaches and technologies** for building IoT and CPSS environments in the context of smart livestock farming, and identification of limitations in their application to pasture-based cattle breeding.
2. **Design and development of a conceptual architecture and prototype IoT platform**, including hardware sensor devices, communication infrastructure, and software tools for real-time data acquisition, processing, and visualization.
3. **Implementation of a Virtual Operations Centre (VOC)** for management and monitoring of behaviour-related data, with integrated functionalities for data visualization and remote control.
4. **Execution of real-world field experiments and analysis of collected data**, leading to insights into the system's effectiveness and potential for behaviour modelling and optimization using AI techniques.

Each of these results corresponds to content presented in the core chapters of the dissertation and demonstrates a logical connection between the theoretical foundation, technical implementation, and practical testing of the developed system.

I consider that the results achieved fulfil the legal requirement for "original contribution to science", as stated in Article 27(1) of the Regulations for the Development of the Academic Staff in the Republic of Bulgaria. The dissertation offers real added value in the fields of applied informatics, IoT-based agricultural systems, and intelligent cyber-physical environments. The research also holds practical significance, especially in the context of sustainable livestock farming and the digital transformation of the agricultural sector.

8. Преценка на публикациите по дисертационния труд

Evgeny Valchev has submitted two scientific publications related to the dissertation, as listed on page 120. Both publications are co-authored and indexed in Scopus, which constitutes a significant scientific contribution in terms of visibility and recognition by the international academic community.

The publications are included in conference proceedings and reflect key aspects of the dissertation work - from the conceptual and architectural foundations to the implementation and application of the IoT-based system in the context of smart livestock farming. They clearly present the main elements of the research described in the dissertation and demonstrate consistency between the publication activity and the conducted scientific work.

No citations are indicated. Nevertheless, the fact that both publications are indexed in Scopus shows that the doctoral student has succeeded in presenting his work at a high scientific level and has passed through a peer-review process that meets international standards.

I consider the publications to be high-quality, relevant, and of sufficient academic weight to meet the regulatory requirements for the award of the doctoral degree, in accordance with Article 2b, paragraph 2 of the Regulations for the Development of the Academic Staff in the Republic of Bulgaria, indicator group G.

9. Personal Contribution of the Doctoral Student

I have no doubts regarding Evgeny Valchev's personal contribution to the conducted dissertation research and to the achievement of the presented scientific-applied and practical results. The exposition in the dissertation is coherent, technically well-grounded, and clearly demonstrates the doctoral student's deep personal involvement in all stages of the development - ranging from theoretical analysis and architectural design to prototyping, conducting experiments, and analysing the results. The writing style, the terminology used, and the practical orientation of the work indicate independent research and a high level of professional competence.

10. Abstract

The abstract of the dissertation is presented in Bulgarian and English, consisting of 33 and 31 pages respectively, and complies with the formal requirements for structure and content. The abstract fulfills its purpose of summarizing the essence of the dissertation and is appropriate in terms of length, clarity, and consistency with the content of the full dissertation.

11. Critical Remarks and Recommendations

The dissertation by Evgeny Valchev is well-structured, scientifically substantiated, and presents an original study with practical orientation. Nevertheless, in the spirit of academic integrity and with the aim of future improvement of the work, I would like to offer the following critical remarks and recommendations:

1. The number of scientific publications related to the dissertation topic is limited - only two publications are presented, although both are indexed in Scopus, thereby meeting the minimum national requirements. It is recommended that the doctoral student expand his publication activity in peer-reviewed outlets, including journals with an impact factor, to ensure broader dissemination of the achieved results.
2. In some parts of the exposition, the language is overly descriptive, particularly in Chapters 2 and 3, where it would be more appropriate to emphasize more clearly the

innovative elements, and the contribution compared to existing solutions. The writing style could be further refined to be more concise and focused.

3. The dissertation lacks an assessment of the sustainability and long-term applicability of the proposed system in real farming conditions, including from financial and operational perspectives. It would be useful in future developments to consider a more in-depth analysis of the economic viability and implementation possibilities in real-world practice.

   In this context, I find it appropriate to pose the following question to the doctoral student: ***In your opinion, what are the main practical obstacles to implementing such a system in a real farming environment in Bulgaria?***

4. No appendices are included with the dissertation, although for this type of applied work (including architectures, code, visualizations, test data), such materials would add clarity and evidentiary value to the exposition. It is advisable to include such information, at least as supplementary material.

These remarks do not diminish the significance of the conducted research but aim to support its future enrichment and refinement.

12. Personal Impressions

I am not personally acquainted with the doctoral student Evgeny Valchev. My impressions are based entirely on the presented dissertation and the accompanying materials. From the exposition of the dissertation, the abstract, and the publications, it is evident that the doctoral student is thorough, focused, and systematic in his research work. He demonstrates serious engagement with the studied problem, strong awareness of the topic, and a clear intention to achieve practical applicability of the developed system. The style of writing, the use of terminology, and the professional presentation of the results indicate independence, discipline, and a high level of competence.

Conclusion

The dissertation contains **scientific-applied** and **applied** results that represent an original contribution to science and meet all the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria (LDASRB), the Regulations for the Implementation of the LDASRB, and the respective regulations of Paisii Hilendarski Plovdiv University. The presented materials and dissertation result fully comply with the minimum national requirements as outlined in the Regulations for the Implementation of the LDASRB.

Based on the above, I confidently give a positive evaluation of the conducted research, as presented through the reviewed dissertation, abstract, achieved results, and contributions, and I recommend to the esteemed scientific jury that the educational and scientific degree “Doctor” be awarded to Evgeny Georgiev Valchev in the field of higher education: 4. Natural Sciences, Mathematics and Informatics, professional field: 4.6. Informatics and Computer Science, doctoral program: Informatics.

23.04.2025 Reviewer: .....

(signature)

(assoc. prof. Emil Doychev, PhD)