REVIEW

by Dr. Vladimir Vassilev Monov,

Professor at the Institute of Information and Communication Technologies - BAS

of a dissertation work for obtaining the educational and scientific degree "Doctor"

in: field of higher education: 4. "Natural Sciences, Mathematics and Informatics" professional field 4.6. "Informatics and Computer Sciences" doctoral program "Informatics"

Author: Evgeni Vladimirov Valchev

Topic: "IOT environment for intelligent animal husbandry" **Scientific supervisors:** Prof. Dr. Stanimir Stoyanov, Prof. Dr. Todorka Glushkova Plovdiv University "Paisiy Hilendarski"

1. General description of the submitted materials

By order No. РД-22-772 of 27.03.2025 of the Rector of Plovdiv University "Paisiy Hilendarski" (PU), I have been appointed as a member of the scientific jury for conducting a procedure for the defense of a dissertation on the topic "IOT environment for intelligent animal husbandry" for the acquisition of the educational and scientific degree "doctor" in the field of higher education 4. "Natural sciences, mathematics and informatics", professional direction 4.6. "Informatics and computer sciences", doctoral program "Informatics". The author of the dissertation is M.Sc. Evgeni Vladimirov Valchev, a doctoral student in full-time study at the Department of "Computer Systems" with scientific supervisors Prof. Dr. Stanimir Nedyalkov Stoyanov and Prof. Dr. Todorka Atanasova Glushkova from PU "Paisiy Hilendarski".

The set of materials presented by Evgeni Valchev is in accordance with Art. 36 (1) of the Regulations for the Development of the Academic Staff of the University of Plovdiv and includes the following documents:

- request to the Rector of the PU for opening of the procedure for the defense of a dissertation;
- curriculum vitae in European format;
- protocol of preliminary discussion of the dissertation in the department and statements of the scientific supervisors on the readiness to open the procedure;
- dissertation work;
- abstract in Bulgarian and English;
- list of scientific publications on the topic of the dissertation;
- copies of the scientific publications;
- declaration of originality and authenticity of the attached documents;
- reference of compliance with the minimum national requirements.

The doctoral student has also attached an official note No. 071 dated 06.03.2025 for participation in a scientific research project from the NPD division of the PU.

The attached documents comply with the regulatory requirements set by the Law on the Development of Academic Staff in the Republic of Bulgaria and the Regulations for its implementation for the acquisition of the educational and scientific degree "Doctor".

2. Brief biographical data of the doctoral student

The attached CV shows that the doctoral student obtained a master's degree in the specialty "Business Informatics with English" in 2019 at the PU "Paisiy Hilendarski". In the period from 2009 to the present, he has been working in the field of information technologies in Bulgarian software and business companies as a business analyst, consultant, project manager. Since 2021, he has been studying in a full-time doctoral program at the Department of Computer Systems, with his main activities and acquired skills being in the areas of IoT systems, cyber-physical networks, application of artificial intelligence in agriculture, animal husbandry and other areas of business. In 2024, he held the position of "assistant" in the Department of Computer Technologies of the University, where he teaches exercises in educational disciplines taught in the university's educational programs. He participates in seminars, works with students and teachers, performs administrative activities.

The candidate's professional qualifications and active work in the field of information technologies and computer systems fully comply with the requirements of the present procedure.

3. Relevance of the topic and pertinence of the set goals and tasks

The set goal and tasks of the dissertation are aimed at the development of an IoT-based cyber-physical platform for intelligent livestock farming. It is planned to create a prototype of a software and hardware platform for intelligent pasture cattle farming with capabilities for studying animal behavior, analysis and processing of the obtained data. The dissertation topic is in line with modern trends for the ever-wider use of digital technologies, intelligent methods and tools in agriculture in order to optimize production processes, develop high-performance technologies and improve the quality of production. The set goal and tasks of the dissertation are well motivated and correspond to the guidelines and perspectives laid down in the National Scientific Programs for the Development of Intelligent Agriculture in Bulgaria. All this undoubtedly determines the current nature of the research conducted in scientific and applied terms, as well as the usefulness of the results obtained in the dissertation.

4. Knowledge of the problem

The introduction and literature review made in Chapter 1 of the dissertation are presented on 40 pages. The characteristics of IoT platforms, cyber-physical and cyber-physical-social systems, as well as the reference architecture of the Virtual Physical Space (ViPS), as a suitable environment for modeling and research in the field of intelligent animal husbandry, are analyzed. Possibilities for applying machine learning methods to create models for analyzing the behavior and life processes of animals are considered. The conclusions to Chapter 1 emphasize the need for the development of intelligent platforms for pasture ecological animal husbandry.

The analytical review made in the problem area of the dissertation shows in-depth knowledge of the subject and current problems, as well as the potential opportunities for finding new solutions with scientific and applied contribution.

5. Research Methodology

The dissertation contains a clearly outlined research methodology, including a step-by-step formulation of the problems to be solved, development of approaches and models, construction of prototypes, testing, analysis and conclusions. The implemented methodological approach meets the set goal and objectives of the dissertation, as a result of which prototypes of a sensor network and a system for collecting and controlling information, as well as a software system for analyzing, processing and visualizing information, have been developed and tested.

6. Characteristics and evaluation of the dissertation work

The dissertation has a volume of 133 pages and consists of an Introduction, 3 chapters, Conclusion, List of publications on the dissertation work and Bibliography. According to the requirements, a Declaration of originality of the results obtained is attached to the dissertation. The list of bibliographical sources includes 111 titles, including sources from Bulgarian and foreign authors. Lists of figures, tables and an alphabet of abbreviations used are attached. The list of publications on the dissertation topic contains 2 titles.

In Chapter 1, an analytical review of modern IoT systems and cyber-physical platforms is made, as well as the opportunities they offer for building intelligent infrastructures in the field of animal husbandry are considered. The need for conducting the dissertation research is justified.

In Chapter 2, a comprehensive approach to building an IoT platform for intelligent animal husbandry is developed. The architectural layers of the platform are defined, the selection and implementation of sensors and sensor networks for open grazing animals and pastures is analyzed. The infrastructure environment and technologies for connectivity between sensor networks and functional servers are determined, the application layer for data systematization, processing and visualization is

developed. The overall content of Chapter 2 demonstrates the high degree of knowledge of the researched problems in theoretical and applied terms, which has enabled the doctoral student to find and propose original and effective solutions to the tasks set.

Chapter 3 examines the stages related to the implementation of the platform for intelligent animal husbandry, as well as the creation of working prototypes of its main components. Two prototypes of IoT sensor devices for monitoring the behavioral characteristics of the observed animals and models of a virtual operational center for managing sensor information and providing services related to animals and farm management have been developed and tested. Empirical data from the work of the developed prototypes are compared and analyzed. The chapter ends with guidelines for future research on the dissertation topic.

The results obtained in the individual chapters of the dissertation are convincingly presented and analyzed. The connection between the tasks set, their development in the structure of the dissertation, the contributions obtained and the publications made is emphasized (table on page 117).

In general, the dissertation is characterized by in-depth knowledge of IoT systems, technologies for building sensor networks, the development and implementation of a complex intelligent infrastructure in the field of modern animal husbandry. The problem area of the dissertation is competently presented, the author's solutions and results obtained are tested and analyzed and meet the set goals and objectives.

In the final part of the dissertation, the contributions of the dissertation are formulated and reports presented by the doctoral student at scientific conferences at which they were presented are indicated.

7. Contributions and significance of the work for science and practice

I accept and positively evaluate the contributions formulated in the dissertation and the abstract. They have a scientific and scientifically applied nature and can be summarized as follows.

- An approach has been proposed for building an intelligent software platform for ecological pasture cattle breeding. The architecture and functional layers of the platform have been developed.
- Prototypes of IoT sensor devices have been created and tested for tracking the behavioral characteristics of open-range grazing animals and the condition of pastures.
- Models of a virtual operational center with components for information management, control over farmed animals and provision of farm management services have been developed.
- A software architecture has been developed for processing and analyzing data for studying the behavior of pasture-raised animals using the created prototypes.

The listed contributions relate to the development of new and improvement of existing methods and approaches in the field of intelligent animal husbandry, as well as the application of modern information technologies and useful practical solutions in this area. They also have the potential for future development with the use of machine learning methods and artificial intelligence for forecasting and optimization of processes in animal husbandry.

8. Assessment of publications on the dissertation work

Two publications on the dissertation topic are presented, which are co-authored, in English and were published in 2021. They are in editions that are referenced and indexed in the Scopus and Web of Science databases, and in both publications the doctoral student is the first co-author. The publications reflect essential parts and main results of the research conducted and meet the requirements for acquiring the educational and scientific degree "doctor". A list of reports by the doctoral student presented at scientific conferences and containing his results on the dissertation research, is additionally included in the dissertation work. This ensures the necessary publicity of the doctoral student's scientific research activity on the topic under consideration.

9. Personal participation of the doctoral student

I know the doctoral student personally and have direct impressions of his work in the National Scientific Program "Intelligent Animal Husbandry". My acquaintance with the dissertation, the abstract and the publications made gives me reason to believe that the dissertation work and its contributions are the personal work of the doctoral student, obtained under the direct supervision of his scientific supervisors. I am not aware of any evidence of plagiarism.

10. Abstract

The abstract is 33 pages long and meets the requirements for its formatting. Its content corresponds to the content of the dissertation and accurately presents the main results of the dissertation work. An abstract of the dissertation in English is also presented in a volume of 31 pages.

11. Critical remarks and recommendations

I have no critical remarks on the substance of the dissertation and the presented results. Of an editorial and technical nature, some inaccuracies and omissions in the text can be pointed out. For example, on pages 15, 16 and 36 there are errors noted regarding the cited sources, two of the functional blocks in Fig. 1 on page 43 are identical and have the same designations, in the Table of Contents on page 4 there is an item "Applications", as such are not presented in the text, etc. These remarks are not on the substance of the work and do not reduce the value of the contributions in the dissertation work.

My recommendation to the doctoral student is to continue the research activity in accordance with the guidelines for future work outlined in the dissertation, as well as the preparation and publication of independent publications in prestigious international journals.

CONCLUSION

I positively assess the work done and the results obtained in the dissertation. The dissertation contains scientific and applied scientific results that represent an original contribution to science and meet all the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria, the Regulations for the Implementation of the Law and the relevant Regulations of the Plovdiv University "Paisiy Hilendarski".

The dissertation shows that the doctoral student possesses in-depth theoretical knowledge and professional skills in the scientific specialty "Informatics", demonstrating qualities and skills for independent conduct of scientific research.

I strongly propose to the esteemed Scientific Jury to award the educational and scientific degree "doctor" to M.Sc. Evgeni Vladimirov Valchev in the field of higher education: 4. "Natural Sciences, Mathematics and Informatics", professional direction 4.6. "Informatics and Computer Sciences", doctoral program "Informatics".

16.04. 2025

Reviewer:

/prof. Dr. Vladimir Monov/