OPINION

For a competition for the academic position "Associate Professor" SN 97/15.11. 2024
With candidate: **Chief Assistant Professor PhD Kristina Ivanova Dineva**

From Prof. DSc Krasimira Stoilova – Institute of Information and Communication Technologies (IICT) – Bulgarian Academy of Sciences (BAS)

By order № 9 from 10.01.2025 of the Director of IICT – BAS, issued on the basis of a decision of the Scientific Council of IICT, protocol №13 from 19.12.2024 I have been appointed as a member of the scientific jury for a competition to occupy the academic position of "Associate Professor" in the field of higher education 4. Natural sciences, mathematics and computer science; professional direction 4.6 „Informatics and Computer Sciences", scientific specialty „Informatics" for the needs of a section „Modeling and Optimization" of IICT - BAS. Only one candidate submitted documents for the announced competition – Chief Assist. Prof. PhD Kristina Ivanova Dineva.

1. General description of the presented materials

Chief Assistant Professor K. Dineva has submitted all necessary materials for participation in the competition according to Art. 10(1) of the Regulations on the specific conditions for acquiring scientific degrees and for occupying academic positions at IICT-BAS.

Chief Assist. Prof. K. Dineva has been a PhD since 18.12.2020.

An official note is presented regarding the total work experience, which is 5 years, of which she worked as a chief assistant for 3 years and 3 months.

2. General characteristics of the scientific and scientific-applied activity

All 17 scientific publications presented do not repeat publications from the dissertation. All publications are in English. Of the publications, 14 have SJR (of which 3 are in quartile Q1 and 1 - in Q2; 4 have IF (sum of IF is 11.3)) and 3 are indexed in Scopus. In 13 of the publications K. Dineva is in first place among the authors, in 1 publication she is in second place, in 2 - in third place and in 1 in fourth place.

The scientific interests of Chief Asst. Prof. K. Dineva, according to the publications for the competition, are related to the design of information systems in connection with the development of the National Scientific Program "Intelligent Animal Husbandry", which can be classified into three main areas:

- *Methods and processes for collecting, analyzing, processing and modeling Data* [Г0-3, Г-8, В-3]
- *Information systems with Machine Learning (ML) and Artificial Intelligence (AI)* [Г-3, Г-1, Г-4, Г-7, Г-9, Г-10, Г-0]
- *Information systems with cloud technologies* [Г-5, Г0-1, Г0-2, Г-2, В-2, В-1]

This classification is conditional, since the majority of publications contain results from all three mentioned areas.

I am not aware of any evidence of plagiarism in the submitted works.

3. Analysis of scientific and applied scientific achievements according to the materials

SCIENTIFIC APPLIED CONTRIBUTIONS

Information systems with Machine Learning (ML) and Artificial Intelligence (AI) [Г-3, Г-1, Г-4, Г-7, Г-9, Г-10, Г-0]

Research in this area is related to the construction of information systems characterized by the collection and processing of heterogeneous data, primarily from IoT devices. Various data processing techniques and machine learning (ML) algorithms have been applied to create models for classification, regression, clustering, anomaly detection, and decision-making recommendations. The results of these studies have been further developed and enriched over time, as per the publications below.

A comparative analysis was made, taking into account the advantages, disadvantages and different areas of real-world applications for each of the four groups of ML algorithms - supervised, unsupervised, semi-supervised and reinforcement learning [Г-3].

An architectural framework is presented with machine learning solutions implemented as a service in a group of microservices [Г-1]. The architectural framework for delivering IoT services is designed following the Agile methodology. The software architecture requirements and expected system functionalities are defined. Machine Learning (ML) analytics for IoT (as a processing paradigm for intelligent handling of IoT data) is presented as part of a micro services platform.

An approach is proposed to build a distributed platform integrating ML and artificial intelligence (AI) models [Г-4]. A messaging system is used that is able to extract, process and analyze information from real-time data from remotely monitored beehives. The collected data is processed, analyzed and then machine learning models are applied. The results obtained are visualized in a special user interface. The main requirements for the developed software platform are clearly defined services, with each service having to perform a strictly defined task without interfering with the operation of other services.

Models have been built, trained to predict future milk production with high accuracy for each individual animal [Г-7]. To achieve this goal, Azure Cloud DataFlow (ADF) was created, which monitors the processes of collecting and storing IoT data, performing data processing, modeling and model evaluation, and visualization of the results. Three regression machine learning models were trained with the data collected from a smart farm. Testing the developed models demonstrated the applicability of the developed Cloud DataFlow, as the Boosted Decision Tree Regression Model showed the highest accuracy in predicting the amount of milk produced by each individual animal.

[Г-9] focuses on recognizing the activity of dairy cows using a non-invasive approach that monitors four key behaviors: licking, eating, standing, and lying down. The study uses IoT devices with accelerometers and gyroscopes attached to the cow's neck to continuously monitor its movements. The data collection process aims to capture the dynamic and static nature of dairy cow behavior, providing a valuable dataset for subsequent analysis. The raw data was analyzed and then Long Short-Term Memory (LSTM) neural networks, a type of recurrent neural network (RNN) suitable for sequential data processing, were used. The LSTM model was trained on the collected sensor data to recognize and classify the four target activities. The model achieves an accuracy of 96%, indicating its robust ability to accurately identify dairy cow activity. Furthermore, the model consistently maintains a low loss value, hovering around 0.25, demonstrating its predictive effectiveness.

The use of data collected from heterogeneous IoT devices in a smart farm is demonstrated [Г-10]. It is proposed to process complex datasets in Cognitive IoT (CIoT), including structured and unstructured data. With machine learning techniques, cognitive IoT systems collect data from multiple sources. The data is processed with various ML algorithms. The results obtained allow for farm management decisions to be made regarding productivity (predicting the expected amount of milk) and monitoring the health status of animals for the purpose of timely detection of diseases (classification task).

A practical solution has been developed for monitoring large farms to classify cow health status based on non-invasive IoT sensors and information about the cow's micro- and macro-environment [Г-0]. The collected data from various sources is processed, modeled and integrated following the proposed workflow. Several machine learning (ML) models are trained and tested to classify the health status of the cow into three categories. A bivariate analysis was applied, which examines how a given characteristic is related to another in the data set. The results are visualized for use by the farmer. The originality of the approach lies in investigating the influence of microenvironments, macroenvironments and cow information on the health status of the cow and whether a combination of these can support and increase the accuracy and reliability of the classification process. To increase the security, speed, and reliability of the workflow, a cloud architecture of services for integrating the trained model is presented as additional functionality in the Amazon Web Services (AWS) environment.

Information systems with cloud technologies [Г-5, Г0-1, Г0-2, Г-2, В-2, В-1]

The research is aimed at solving problems related to increasing the productivity and efficiency of computing processes through the integration of cloud technologies and the construction of modern infrastructures. Effective approaches have been applied to develop scalable cloud infrastructures that provide reliable data management, real-time visualization, and process optimization.

A scalable IoT architecture for livestock farming is proposed [Г-5, Г0-1]. This architecture is developed following Amazon Web Services (AWS) best practices with the ability to provide a reliable, secure, efficient, and cost-effective cloud system for IoT applications. The architecture includes IoT livestock devices and IoT Edge devices that communicate with each other according to predefined rules. IoT Livestock devices can send the heterogeneous data they collect to the IoT Edge device in two ways – via WiFi and LoRaWAN. Supporting both protocols simultaneously in the system gives it an advantage over other similar systems, as it allows sending collected data to IoT Edge from animals on the farm (close range) and animals in remote pastures (long range). The proposed architecture allows the IoT Edge device to include both newly built IoT Livestock devices and existing similar devices that are already integrated in various farms. In addition to flexibility and easy adaptability, the proposed architecture provides centralized device management, big data processing capabilities, and ML application. All collected data is sent for storage and processing to the AWS cloud.

In [Г0-2], a systematized methodology of the logical sequence of all necessary steps, grouped into layers for processing and modeling heterogeneous IoT data, is presented. An integration layer with several stages for incorporating and validating a trained ML model in a real environment is also included. Comprehensive creation of automated data processing workflows is offered. All aspects of the workflow for classification and regression tasks are covered, from problem definition to deployment of a ready-made solution in the production environment.

Modeling and simulations of digital twins for smart agriculture in a cloud environment have been performed [Г-2]. Digital twins can be used not only to monitor and simulate the effects of interventions, but also to remotely control objects using automated actuators. Digital twins are important for traceability, compliance and learning, as they provide measurable data to increase resilience.

In [В-2], a scalable cloud architecture of an intelligent livestock monitoring system based on Amazon Web Services (AWS) is designed using cyber-physical systems (CPS) and Internet of Things (IoT) equipment and a wide range of cloud services. The services used in the AWS cloud are described in detail and their tasks are clarified according to the application area. The proposed architecture is able to process the required amount of data and allows the CPS-IoT infrastructure to use automated scaling mechanisms.

An intelligent monitoring system is designed that integrates existing IoT devices into already built systems deployed in smart farms [B-1]. The proposed architecture allows for data extraction from IoT devices, data storage, data preparation and transformation, modeling, and visualization. With continuous data transmission from IoT devices, interactive real-time reports can be generated along with built-in machine learning (ML) models. As a result of the proposed intelligent monitoring system, the collected data and ML modeling results are visualized interactively using a powerful dynamic dashboard, which allows users to monitor various parameters on the farm and provides an accessible way to detect trends, deviations, and patterns in the data and machine learning results.

The proposed solution is fully cloud-based using the Microsoft Azure cloud computing platform, featuring flexible deployment of IoT, AI/ML solutions, and security. The proposed monitoring system relies on Azure cloud services, technologies, and infrastructures. Of the 200 available types of Azure services, 6 are included in the information system: IoT Hub, Blob (binary large object) Storages, streaming services, AzureMachine Learning Studio, Power BI (business intelligence), and others. Each service used bears its own responsibility, following the single responsibility approach. The results of the system testing show no data loss. The average data transmission delay is 5.19 s. No errors occurred during communications, which proves the functionality of the built system.

I highly appreciate publication [B-1], which is the best article by K. Dineva, written professionally, containing a completed study of a designed information system with integration of data collected from IoT devices, built-in machine learning models, selection of appropriate cloud services, good visualization of the results, and proven functionality of the system.

SCIENTIFIC APPLIED AND APPLIED CONTRIBUTIONS

Methods and processes for collecting, analyzing, processing and modeling Data [Г0-3, Г-8, B-3]

A specialized multi-sensor device for studying air quality in the working environment of the livestock farm has been proposed in [Г0-3]. The developed system is low-cost and based on open source software. Having data on the animals' micro and macro environments, combined with their individual records, allows for deeper analysis of this data for better farm management.

An approach has been developed to analyze cow behavior patterns using IoT devices [Г-8]. The results not only contribute to monitoring cow behavior, but also have potential implications for livestock management, health monitoring, and precision agriculture. This article applies two main techniques, median filtering and fast Fourier transformation (FFT), to improve signal quality and facilitate frequency domain analysis.

A multi-sensor air quality monitoring system was built using open source tools and low-cost sensors as a precision livestock farming (PLF) tool [B-3]. The system adheres to the SOLID principles, ensuring its sustainability, scalability, and ease of operation. The meaning of SOLID is S - Single Responsibility Principle; O - Open-Closed Principle; L - Liskov Substitution Principle; I - Interface Separation Principle; D - Dependency Inversion Principle. Analysis of data collected by the multisensory device reveals dependencies on environmental conditions in the monitored room. Time series and correlation analyses show interactions between key environmental parameters. These interrelationships highlight the critical impact of these elements on air quality. The developed multi-sensor system is cost-effective due to the use of inexpensive sensors and open source tools, which significantly reduces the overall cost of the system while providing high data accuracy and reliability.

I positively assess the candidate's scientific and applied contributions in the three main research areas presented.

4. **Citations**

The observed citations of the publications submitted for participation in the competition are 48, with the citing publications being in publications indexed and referenced in Scopus and/or Web of Science.

5. **Fulfillment of minimum requirements and other activities**

Chief Assistant K. Dineva fulfills and exceeds all the indicators of the Regulations on the specific conditions for acquiring scientific degrees and for occupying academic positions at IICT-BAS, the minimum requirements for the academic position of "Associated Professor". Requirements/performance for individual indicators is as follows: indicator A - 50/**50**; B - 100/**140;** Г – 140/**286;** D – 70/**288**; E – 20/**70**.

Chief Assistant K. Dineva participates in 3 projects: National Scientific Program Intelligent Husbandry, 2021-2024; National Scientific Program Security and Defense, 2022-2025; and project with Bulgarian Research Fund, 2024-2028.

Chief Assistant K. Dineva has active scientific research and applied science activities.

Recognition for this is the prestigious diploma awarded to her by the Bulgarian Academy of Sciences "Professor Marin Drinov" for young scientists under 35 years of age in 2021.

Conclusion. Based on the presented materials, the scientific-applied and applied contributions, as well as the comprehensive assessment of the other indicators of the competition, **I give a positive assessment** and **I srtongly recommend to the Honorable Jury** to propose to the Scientific Council of IICT-BAS **to elect Chief Assistant Professor PhD Kristina Dineva** for the academic position of "**Associate Professor**" for the needs of the "Modeling and Optimization" department at IICT-BAS, professional field 4.6 "Informatics and Computer Science", specialty "Informatics".

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