Abstracts of the scientific work

of **Asya Todorova Toskova**

for participation in a procedure for the academic position "associate professor"

1. Toskova A. (2023) **Some Studies in Machine Learning – Computer Vision & Recommendation**, Monograph, ISBN: 978-619-245-399-2, Publisher: Prof. Marin Drinov Publishing House of Bulgarian Academy of Sciences.

At the Faculty of Mathematics and Informatics of Plovdiv University "Paisii Hilendarski", under the leadership of Prof. Dr. Stanimir Stoyanov, a Virtual Physical Social Space (ViPS) is being developed, in which many active and passive software components interact – intelligent agents and services. The space enables the integration of the virtual world with the physical world by incorporating software and hardware IoT nodes. This allows it to serve various application areas, such as education and training, cultural and historical heritage, agriculture and animal husbandry, medicine, smart cities, etc. The development of various modules is the basis for expanding the capabilities of the integrated environment. For this purpose, three modules were realized to solve concrete problems – recognition of weeds in wheat, recognition of Bulgarian embroidery and recommendation of serious games for children with special educational needs. The modules are based on classification algorithms. The challenge is to find out which methods work best on the same data. Numerous experiments were conducted to implement the modules.

2. A. Toskova, B. Toskov (2023) **A Deep Learning Wheat-Weed Dataset**, International Conference Automatics and Informatics`2023 (ICAI'23), pp. 502-507, E-ISBN: 979-8-3503-1291-1, PoD-ISBN: 979-8-3503-1292-8, Publisher: IEEE
https://doi.org/10.1109/ICAI58806.2023.10339055

The article presents the Wheat-Weed Dataset – the first dataset on weeds in wheat grown on the territory of Bulgaria. The set contains 4647 unique images belonging to 7 plant species. The images are full color and annotated. To evaluate the effectiveness of the base, two deep networks with different characteristics were trained on it. During the study, numerous experiments were performed with different combinations of the

hyperparameters. The results obtained are excellent. Wheat-Weed Dataset is freely available.

3. A. Toskova, B. Toskov (2023) **Comparative analysis of algorithms for wheat weed recognition**, International Conference Automatics and Informatics`2023 (ICAI'23), pp. 205-210, E-ISBN: 979-8-3503-1291-1, PoD-ISBN: 979-8-3503-1292-8, Publisher: IEEE https://doi.org/10.1109/ICAI58806.2023.10339096

The article presents a research and comparative analysis of the performance and accuracy of several state-of-the-art Deep Convolutional Networks tasked with recognizing common weeds in the wheat field. Twelve plant species were classified using images from the publicly available V2 Plant Seedlings Dataset. Two types of new networks were created and trained and four other basic models for transfer learning were used. During the study, numerous experiments were conducted with different combinations of hyperparameters of the networks and database processing and balancing techniques were applied. The best performance was obtained with a self-created small CNN 18 (96%) and with a large pre-trained Inception ResNet V2 (98%).

4. Toskova A., G. Penchev (2021) **Intelligent Game Recommendation System**. AIP Conference Proceedings, vol. 2333, no. 1, Article number 050007, pp. 1-8, 46th International Conference on Applications of Mathematics in Engineering and Economics (AMEE 2020); ISSN: 0094-243X, ISBN: 978-073544077-7, Publisher: AIP, https://doi.org/10.1063/5.0042063

The technologically advanced learning implies the adaptation of the recommendation systems to the specific wishes and capabilities of the users. The present document proposes an intelligent system designed for the encompassing education of students with special educational needs. The system integrates the capabilities of intelligent agents, the recommendation systems, and the game based learning in order to provide a personalized learning content. A Bayesian Classifier recommends educational games depending on the interests and the preferences of the users, and a multi-agent system provides individual needs by analyzing users' behavior and by determining the need of acquisition of certain knowledge and skills appropriate for the level of learning.

5. Toskov B., A. Toskova, S. Bogdanov and N. Spasova (2021) **Intelligent IoT Gateway**, International Conference Automatics and Informatics (ICAI), pp. 374-377, E-ISBN: 978-1-6654-2661-9, ISBN: 978-1-6654-2662-6, Publisher: IEEE, https://doi.org/10.1109/ICAI52893.2021.9639779

The article proposes a model of an intelligent gateway as a component for building a smart IoT (Internet of Things) network. The main advantage of this gateway is the additional ability to control end devices by using intelligent software agents. Their main purpose is to ensure the continuous and correct operation of end devices when the Internet connection is interrupted. To ensure the communication between agents and end devices, a modified protocol based on the publishing-subscribing concept provided by the MQTT (Message Queuing Telemetry Transport) broker is proposed.

6. Toskov B., A. Toskova, S. Bogdanov and N. Spasova (2021) **Intelligent Management of IoT Devices with Limited Connectivity**, 2021 International Conference Automatics and Informatics (ICAI), pp. 354-357, E-ISBN: 978-1-6654-2661-9, ISBN: 978-1-6654-2662-6, Publisher: IEEE, https://doi.org/10.1109/ICAI52893.2021.9639653

In this paper, we have presented an IoT (Internet of Things) architecture that provides the possibility to realize intelligent agents that communicate with heterogeneous devices. These devices can be part of a capillary system built on different technologies such as Wi-Fi, Zigbee, Z-wave, etc. covering the IEEE 802.15.4 communication standard, as well as remote communication networks such as LoRaWAN, Sigfox, NB-IoT, etc. One of the aspects of the architecture created is the ability to move the intelligent part of the system to the local network, which prevents the loss of data in case of lack of connectivity. The future goal is to integrate the developed architecture into the generic multi-service cloud-based IoT operational platform EMULSION.

7. Stoyanova-Doycheva A., E. Doychev, S. Stoyanov, A. Toskova (2020). **An Intelligent Gene Bank Management System**. ICAI2020 International Conference Automatics and Informatics, E-ISBN: 978-1-7281-9308-3, PoD ISBN: 978-1-7281-9309-0, Publisher: IEEE, https://doi.org/10.1109/ICAI50593.2020.9311295

The article aims to present the GenBank System for managing the gene bank in the Institute for Plant Genetic Resources in the town of Sadovo (IPGR). The functionality and

architecture of the system are described. Some aspects of the intelligence of the architecture are considered, namely operational assistants as part of the architecture and an ontology for storage and processing of data on plant genetic resources.

8. Toskova A., Uhr, Z., Stoyanov, S., Toskov, B. (2020). **DCNN against Wheat Weeds**. Problems of Engineering Cybernetics and Robotics, Vol. 74, ISSN: 2738-7356, e-ISSN: 2738-7364, (pp. 41-50), Publishing House „Prof. Marin Drinov", Bulgarian Academy of Science,

https://doi.org/10.7546/PECR.74.20.05

The article presents a classification model for detecting some common and economically important weeds in wheat crops in Bulgaria. For this purpose a deep convolutional neural network (DCNN) has been created. The dataset contains full-color images of wheat and six early-stage weeds. The data represents a selected and processed part of the existing V2 Plant Seedlings Dataset. DCNN is trained to recognize 7 classes. The network is trained on images from scratch. The model successfully classifies the test set with an accuracy of 92%. It is expected that applying the classifier in a real work environment will automate and speed up the process of identifying weeds and will be useful for both their early removal and limiting the amount of harmful herbicides.

9. Тоскова А. (2020). **Модел на препоръчваща система в интелигентна игровобазирана обучителна платформа**. "Автоматика и Информатика" 3/2019, Print ISSN 0861-7562, Online ISSN 2683-1279, pp. 29-33, Съюз по автоматика и информатика "Джон Атанасов", https://sai-bg.com/wp-content/uploads/2020/10/AI-3-2019.pdf

This article presents an approach for creating a content recommendation model in a game-based learning platform designed for students with special educational needs. Various referral systems and existing opportunities for intelligent delivery of personalized learning content tailored to the individual needs of children are addressed.

10. Тосков Б., А. Тоскова (2020). **Мултиагентна сензорна мрежа**. "Автоматика и Информатика" 2/2019, Print ISSN 0861-7562, Online ISSN 2683-1279, pp. 22-26, Съюз по автоматика и информатика "Джон Атанасов",

https://sai-bg.com/wp-content/uploads/2020/10/AI-2-2019.pdf

This publication presents an experimental model of the architecture of an intelligent guard system developed on the concept of IoT. The Guard System is part of the cyber-physical space of the Faculty of Mathematics and Informatics at Plovdiv University. This model is built with JADEX intelligent agents and hardware sensors working on WiFi sensor network.

11. Toskova A., B. Toskov, Z. Uhr, L. Doukovska (2020). **Recognition of Wheat Pests**. In 2020 IEEE 10th International Conference on Intelligent Systems (IS), pp. 276-280, ISSN: 1541-1672, Publisher: IEEE, https://doi.org/10.1109/IS48319.2020.9200148

This article introduces a model of an intelligent system for the recognition of wheat crops pests. The recognition allows us to define the species of weeds, their density, the various diseases and vermin of beneficial plants, as well as the exact location of ob¬jects in the field. The recognition technology is based on a convolutional neural network and on the independent work of a drone.

12. Toskov B., A. Toskova, S. Stoyanov, E. Doychev (2020). **Architecture of Intelligent Guard System in the Virtual Physical Space**. In 2020 IEEE 10th International Conference on Intelligent Systems (IS) pp. 265-269, ISSN: 1541-1672, Publisher: IEEE, https://doi.org/10.1109/IS48319.2020.9200177

The article presents an architecture for creating a guard system built with intelligent software agents that connect with the physical world through a sensor network. The Guard System is part of the Virtual Physical Space (ViPS). In ViPS, it is built as an Internet-of-Things ecosystem consisting of autonomous intelligent components.

13. Toskova A., G. Penchev (2020). **Recognition of Bulgarian Embroidery with Recurrent Neural Network**. In 2020 IEEE 10th International Conference on Intelligent Systems (IS), pp. 252-257, ISSN: 1541-1672, Publisher: IEEE, https://doi.org/10.1109/IS48319.2020.9199845

This article explores the possibilities for the recognition of Bulgarian embroidery by intelligent multi-agent system. The task of recognizing the embroidery is divided into three distinct parts – recognition of an image as an embroidery, determination of the embroidery as a Bulgarian and its classification according to the area of workmanship.

The proposed method uses Hopfield neural network to solve the first task. Results from Java-based algorithm are presented.

14. Penchev G., A. Toskova (2020) **Intelligent Failure Forecast and Preventive Maintenance System**. In 2020 IEEE 10th International Conference on Intelligent Systems (IS) pp. 557-561, ISSN: 1541-1672, Publisher: IEEE, https://doi.org/10.1109/IS48319.2020.9199974

This paper presents an intelligent modular system designed for failure forecast and preventive maintenance in aviation. The proposed system allows the detection of parts with a potential risk of premature failure. The architecture of the system, the technologies used for its development, as well as the operation of the individual modules are described. Communication between modules is based on web services. It is presented a conceptual model for the training of the intelligent components, operating in the environment.

15. Toskova A., B. Toskov, S. Stoyanov, I. Popchev (2019). **Genetic Algorithm for a Learning Humanoid Robot**. In Comptes rendus de l'Acade'mie bulgare des Sciences, 72 (8) pp. 1102-1110, ISSN 13101331 (Print), ISSN 2367–5535 (Online), Bulgarian Academy of Sciences Publishing House „Prof. Marin Drinov", https://doi.org/10.7546/CRABS.2019.08.13

An intelligent agent learning module was developed in Java. It improves the speed of a humanoid robot Nao in a simulated environment. The approach is focused on minimizing the joints spinning times as learning parameters in a genetic algorithm. Various combinations of genetic parameters have been examined and evaluated in the experimental process.

16. Toskov B., A. Toskova (2019). **Smart sensor network**. Proceedings of International Conference Automatics and Informatics'2019 (ICAI'19), (pp. 237-240). Sofia, ISNN 1313-1850.

A concept for building an intelligent system based on independently operating modules is presented. The system represents a reference basis for creating intelligent IoT applications. It includes wireless sensors connected in a WiFi network and intelligent agents.

17. Тоскова А. (2019). **EXPERT-L**. Сборник с доклади "Форум НАУКА 2017/2018", УИ „П. Хилендарски", Пловдив, ISBN 978-619-202-525-0, pp. 200-215.

This paper describes the theoretical model and the realized prototype of a self-learning intelligent personal assistant operating on a humanoid robot. The developed Java module improves the speed of the robot in a simulated environment. The approach uses a genetic algorithm to find the best times to move the robot joints.

18. Тосков, Б., А. Тоскова, Русев, Д. (2018). **Система от гардове в кибер-физическото пространство**. Computer science and communications, 7(1), БСУ, ISSN 1314-7846, ISBN 978-619-7126-57-0, (pp. 119-124),
https://csc.bfu.bg/index.php/CSC/article/view/2

This publication presents an intelligent system architecture model developed on the concept of IoT. It is built from intelligent agents and hardware components, ensuring personalization and normal flow of the learning process.

19. Ivanova V., A. Toskova, A. Stoyanova-Doycheva, S. Stoyanov, M. Veselinova (2017). **Lifelong learning in Virtual education space with intelligent assistants**. Proceedings of the 8th Balkan Conference in Informatics 2017, BCI'17, Scopje. ISBN: 978-1-4503-5285-7/17/09, ACM International Conference Proceeding Series (ICPS), Part F130953, art. no. a19, pp. 1-6, https://doi.org/10.1145/3136273.3136287

This article presents an approach to ensure lifelong learning in the virtual educational space that is being developed at the Plovdiv University. It describes intelligent agents that solve various tasks in the space. One of the future tasks is to expand the learning content for the field of cognitive robotics. To this end, the first version of an electronic textbook was developed and presented.

20. Стоянов С., А. Тоскова, Тодоров, Й., Русев, Д. (2017). **Проект EXPERT-L**. International Conference "Automatics and Informatics'2017", София, ISSN 1313-1850, pp. 291-294.

This paper presents the EXPERT-L project that is being implemented in the DeLC laboratory at the Plovdiv University. The project aims to create a personal assistant operating on a humanoid robot which can learn. The main stages of the project are presented in detail.

21. Stoyanov S., T. Glushkova, A. Stoyanova-Doycheva, J. Todorov, A. Toskova (2020). **A Generic Architecture for Cyber-Physical-Social Space Applications**. In S. V. Jardim-Goncalves R. (Ed.), Intelligent Systems: Theory, Research and Innovation in Applications. Studies in Computational Intelligence, vol 864, eBook Packages: Intelligent Technologies and Robotics (pp. 319-344). Online ISBN 978-3-030-38704-4, Print ISBN 978-3-030-38703-7, Springer, Cham, https://doi.org/10.1007/978-3-030-38704-4_14

This paper briefly presents a reference architecture called Virtual Physical Space. The purpose of the architecture is to adapt to the development of various Cyber-Physical-Social applications. In the paper, the basic components of the space are described in more detail. Adapting the proposed architecture to implement an intelligent personal touristic guide is also considered.

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