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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Alexander Menshchikov

PhD Program: Computational and Data Science and Engineering

Title of Thesis: Mathematical Modelling and Analysis of Intelligent Monitoring Platform for Precision Agriculture

Supervisor: Assistant Professor Andrey Somov

Date of Thesis Defense: 09 October 2020

Name of the Reviewer: Mariia Pukalchik

Name of the Reviewer:

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Signature:**  **Date: 09-09-2020**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art

- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

During the Ph.D. study, Alexander conducted high-quality research on a wide variety of problems in the Internet of Things (IoT), applied mechanics, and precision agriculture. His primary focus was on developing and implementing data-driven approaches for real-time robust, and accurate semantic segmentation of harmful plants onboard of the Unmanned Aerial Vehicle (UAV). He reflected all obtained results in a clear and structured way. The topic of the dissertation is corresponding to its' actual content. The overall quality of the thesis is high, structure, and the style of narration and explanation of the results allow readers to understand the problematic aspects of the conducted research.

Alexander was able to set up a very extensive and comprehensive analysis of the state of the art and applied only modern Artificial Intelligence (AI) and optimization techniques to solve the problems. As an AI technology, he widely used Fully Convolutional Neural Networks (FCNN) for performing computer vision tasks such as segmentation for creating a smart portable monitoring system that allows detecting harmful plants as hogweed during the flight onboard of the UAV in the real-time. He trained several ANNs to predict plants growing in artificial systems. Thus, the computer vision system was subsequently approbated in the climate chamber in a greenhouse and on the autonomous vehicle. The development of this software was a major outcome of the thesis and for sure required a lot of work. The author demonstrated the efficiency and effectiveness of his approaches *in situ*. These studies demonstrate also the application of the methods and processes developed in the frame of the thesis in the real agricultural practice.

As an applied mechanics technology, he proposes the Morphing Wing prototype to prolong the flight distance of the UAV and improve its controllability. This subsystem was tested step-by-step from numerical investigation to experimental study in the aerodynamics laboratory. The obtained by implementation of morphing wing results are novel and have a vast potential for practical usage. All the methods mentioned above are highly relevant in current state-of-the-art research in precision agriculture, which is proved by recent developments in the modern agricultural companies and publications in the most recognizable journals. Since it can significantly improve the operation of the traditional agromonitoring platforms, which have limited capabilities for long-distance flight, and data-intensive computations onboard. The reduction of the overall power consumption leads to the prolongation of data-intensive calculations on board.

One of Alexander's research's critical features is that he implemented end-to-end solutions, so this opens the vast possibilities for direct industrial application of obtained results. He also paid attention to the universality of proposed approaches. Therefore, they are attractive to use in practice. The practical usefulness was proved in the Moscow region experiment, where developed Computer vision and Machine learning system allowed to determine hotspots spread of the hogweed in real-time during the flight. Since such an experiment is unique, then the obtained dataset is highly relevant for testing future similar industrial systems. Alexander's research connects the lab research with industrial applications. His research complements a comprehensive view of the plant localization in controlled environments and the wild. In particular, he proposed and created the system for automatical seed germination rate assessment;

for tomatoes plant grow prediction; and for hogweed semantic segmentation using Computer vision approaches. This system is accurate, novel, and in high demand to investigate plant growth dynamics, which is highly essential for future plant development.

The research work developed in the thesis was also reported in several good quality papers by the author. Alexander published research papers mainly in Q1 journals or in recognizable conferences in the IEEE society. He published eight research papers and issued one patent.

Journals:

- "IEEE Sensors journal" **(Q1) IF=3; (First author)**
- "IEEE Transactions on Instrumentation and Measurement" **(Q1) IF=3; (First author)**
- "Physics of Fluids" **(Q1) IF=2.6; (First author)**
- "Austrian Journal of Natural and Technical Science" **(First author)**

Conference papers:

- IEEE ETFA 2020 - the 25th International Conference on Emerging Technologies and Factory Automation, 2020 **(First author)**
- IECON 2019 - 45th Annual Conference of the IEEE Industrial Electronics Society (IES), 2019 **(First author)**
- 13th IEEE International Symposium on Industrial Embedded Systems), 2018 **(First author)**
- Global IoT Summit (GIoTS), 2019; **(Third author)**

Patent:

- **A. Menshchikov.** "Airflow 2.0" RU #2018618762, 2018. Topic: "2D Computational Fluid Dynamics Simulator and Optimizer of 2D Airfoils".

The quality of publications is high. All papers were carefully reviewed. The scientific significance of the results is recognized on the international level, complementing, and defining current state-of-the-art research.

Provisional Recommendation

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*