

Jury Member Report - Doctor of Philosophy thesis.


Name of Candidate: Dmitry Shadrin

PhD Program: CDSE

Title of thesis: Data-driven modeling of plant growth dynamics in controlled environments

Supervisor: Professor Maxim V. Fedorov, Skoltech

Name of the Reviewer: Vladimir V. Palyulin

I confirm the absence of any conflict of interest	Signature:  Date: 15-09-2020
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Reviewer's Report
<p>The manuscript "DATA-DRIVEN MODELING OF PLANT GROWTH DYNAMICS IN CONTROLLED ENVIRONMENTS" submitted as a PhD thesis by Dmitry Shadrin is devoted to applications of modern data science techniques to such an important agricultural problem as the plant growth dynamics. The thesis consists of 6 chapters and is based on 12 published and 1 accepted papers published in journals and conference proceedings. Among them 3 first author papers are published in Q1 journals indexed in WOS/Scopus and a couple of papers are published in Q1 WOS/Scopus indexed journals with Dmitry being the second or the third author. This securely fulfils the requirements of the PhD thesis defence policy of Skoltech.</p> <p>The text consists of 2 introductory review chapters, 3 chapters describing the results obtained by the defendant and the conclusion section. The first introductory part includes a very detailed description of the thesis goals and structure. It very meticulously highlights the degree of personal contribution of the defendant to the papers. The chapter also includes an analysis of worldwide research and financial priorities in digital agriculture. This analysis is not a typical part of a PhD thesis, but is a good find and adds a lot to the understanding of importance and the motivation of the work. The second chapter is a standard review of the topics and methods used in</p>

the thesis. The last subsection of the chapter reproduces known solutions for the 1D analytical model of plant growth described in classical literature. With all the limitations of such models the presented plots help to acquire an understanding of simple cases. The next section, chapter 3, already shows the new results obtained by the defendant and is generally devoted to hybrid analysis. It first describes the unique experimental setup, the monitoring system and the data acquisition. Next it shows the first modelling approach based on Kalman filtering and logistic growth model. The analysis reveals that this novel approach has a high computational efficiency while keeping a good accuracy. The chapter continues with a description of instance segmentation for more detailed characterisation of the growth and concludes with dynamic mode decomposition approach as well as the problem of merging the information from 2D and 3D images. Altogether the chapter collects the impressive four different data science techniques for the biomass growth prediction and analysis. The chapter 4 goes further with the development of new data-driven techniques in agriculture. It starts with recurrent neural network applications for the growth prediction and then continues with the description of a large-scale experiment performed in Michurinsk. The data were treated with convolutional neural networks. The second half of the chapter tackles practically important problems of germination detection and quantification and the remote plant diseases detection. The main goal of the latter study is to build a detection system which helps the identification of a disease at an early stage. I personally find this latter piece of work to be very promising and believe that it is strongly needed in industry. The last chapter with novel results concentrates on such ubiquitous and critical factor of agricultural sustainability as environmental predictions. The two considered problems are machine learning for water quality assessment and the toxicity effects of various pollutants. The last chapter summarises the findings and the novelty of the whole thesis.

Overall I am very impressed by the diversity and comprehensiveness of the approaches used in this thesis. Yet the text is very cohesive and makes a very good impression of the consistent and ideologically unified study. Moreover, within just four years the defendant managed to produce both experimental studies and elaborated theoretical models. The treatise presents a significant advancement of the field. In combination with high quality papers it highlights the ability of the author to implement the cutting-edge techniques, his deep knowledge of the pertinent literature and the capability to use them to produce trustworthy scientific results.

I would like to point out a minor issue which could be discussed to further improve the quality of the work. I am concerned that the methods used could have their limitations. I understand that mostly the thesis is a proof of concept that data-driven methods solve and simplify many problems. This is shown pretty well. However, I would appreciate to see a brief analysis of applicability and possible limits as a part of the text (possibly in conclusion subsections of main chapters).

Apart from this general remark I have a list of minor corrections

Figure 1-2 contains typos in the word “engineering”

The punctuation in equations is missing. Normally, equations are considered as parts of the sentences and one expects a comma, a full stop or a continuation of the sentence after the end of an equation.

Across the text there is a systematic capitalisation of first letters of the terms referring to various methods. While their acronyms are indeed made of capital letters it is not true for the full words unless they involve surnames (or copyright protected names such as Web of Science, for instance). I suggest decapitalisation of all these cases.

In a few places in the text and figure captions the word “photos” is used. I would suggest a more scientifically sound “images” or “pictures”

Figure 5-1 has a term New Moscow which I would consider a spoken jargon rather than something to be used in the scientific text. I would suggest “Newly added territories in 2011”.

There are also a few typos across the manuscript to be taken care of.

Provisional Recommendation

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

~~*I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*~~

~~*The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*~~