UNIWERSYTET
WARMIŃSKO-MAZURSKI W OLSZTYNIE
WYDZIAŁ LEKARSKI, COLLEGIUM MEDICUM

Department of Ophthalmology

Olsztyn, 10.08.2022

Review of the doctoral dissertation of mgr inż. Dominiki Sułot entitled *„Development of machine learning algorithms operating on small datasets to assist in the diagnosis of eye diseases"*

After decades of slow progress artificial intelligence (AI) has finally brought many new technologies and applications, including health care. It is believed that AI holds the potential to improve patient and practitioner outcomes, reduce costs by preventing errors and unnecessary procedures, and provide population-wide health improvements. AI-based technologies employing deep-learning (DL) approaches have proven effective in supporting decisions in many medical specialties, including radiology, cardiology, oncology, dermatology, ophthalmology, and others. For example, AI/DL algorithms have been shown to reduce waiting times, improve medication adherence, customize insulin dosages, and help interpret magnetic resonance images. AI/DL algorithms have been used to detect diseases based on image analysis, with fundus photos and optical coherence tomography (OCT) scans analyzed for retinal diseases, chest radiographs assessed for lung diseases, and skin photos analyzed for skin disorders. DL algorithm training requires large data sets with thousands or even hundreds of thousands of diverse, well-balanced, and accurately labeled images. The enormous numbers of required images rarely can be obtained from individual centers, thus the problem of AI/DL algorithms operating on small datasets is very important and up-to-date.

WYDZIAŁ LEKARSKI, COLLEGIUM MEDICUM / KATEDRA OKULISTYKI
UNIWERSYTET WARMIŃSKO-MAZURSKI W OLSZTYNIE
Al. Warszawska 30, 10-082 Olsztyn
tel. (89) **524 55 39**
wl.uwm.edu.pl

Due to the above, the selected topic of the doctoral dissertation is not only very important, but also original. The thesis submitted for evaluation has a typical layout for doctoral dissertations. It is presented on 111 pages and contains all the required structural elements typical of a scientific work. It has a list of

abbreviations and tables used in the work, which makes it easier to read. The work contains 12 tables, 40 illustrations and 123 references. The introduction extensively discusses the issues of the work undertaken, including standard machine learning algorithms, deep learning, quality assessment metrics used in machine learning, the course of dimensionality, methods to deal with low-data regime, and different applications of machine learning in Ophthalmology.

The aim of the work and research hypotheses have been formulated accurately and precisely. The aim of the study was to define the assessment of machine learning algorithms operating on small datasets to assist in the diagnosis of eye diseases.

The work methodology was well chosen and described in detail. A retrospective local dataset, which was collected during another study was used. The experimental part of the work was divided into four divisions corresponding to the four main hypotheses of the thesis. The first two experiments used two popular machine learning tasks that included image classification and segmentation in low-data regime. The first hypothesis was that low-resolution Scanning Laser Ophthalmoscopy (SLO) images contain substantial information that can support glaucoma diagnosis especially when combined with the use of deep learning algorithms. The second hypothesis assumed that the size of the data fed into a neural network can have a significant impact on performance, particularly in the case of Bruch's membrane opening segmentation, the shape of input data can affect the final results of the trained model despite using the same dataset across different models.

During the first experiment several approaches for handling small dataset were implemented and tested and the results showed that the best solution is to use

WYDZIAŁ LEKARSKI, COLLEGIUM MEDICUM / KATEDRA OKULISTYKI
UNIWERSYTET WARMIŃSKO-MAZURSKI W OLSZTYNIE
Al. Warszawska 30, 10-082 Olsztyn
tel. (89) **524 55 39**
wl.uwm.edu.pl

different approaches to deal with the low-data regime. Moreover, the it was showed that SLO images contain useful information that can be used for the diagnosis of glaucoma. In the second experiment it was shown that the U-Net architecture obtained the best accuracy in this task. The authors obtained a mean absolute error around 1 pixel for determining the opening position of the Bruch's membrane. Moreover, procedures such as data augmentation can further increase the final accuracy of the model.

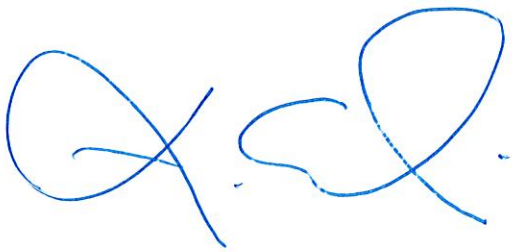
The other two experiments proposed and tested solutions focused on overcoming the problem of small datasets. They used classification using additional feature selection methods and the general approach to convolutional networks and low-data regime. The third hypothesis was that machine learning algorithm can be successfully applied in the low-data regime applications, provided they are equipped with some additional techniques to deal with a small data set; and the fourth hypothesis that the use of orthogonalization with convolutional networks can have a significant positive impact on performance particularly when the model is trained on small data sets. In both of these parts, the authors showed that that by using proposed methodology it was possible to improve performance They concluded, that custom smaller task-specific architectures may perform better than standard large ones and that orthogonalization provide performance improvement in convolutional networks.

The obtained results were discussed in the text of the work appropriately, avoiding unnecessary repetitions. The discussion of the thesis was presented correctly and includes a discussion of the obtained results against the available research in international literature and a discussion of the significance of the obtained own results. The author formulated correct conclusions consistent with the stated aim of the work and the results of the research. A minor editorial problem is the lack of citation of the reference No. 7 in the text.

WYDZIAŁ LEKARSKI, COLLEGIUM MEDICUM / KATEDRA OKULISTYKI
UNIWERSYTET WARMIŃSKO-MAZURSKI W OLSZTYNIE
Al. Warszawska 30, 10-082 Olsztyn
tel. (89) **524 55 39**
wl.uwm.edu.pl

I believe that the reviewed doctoral dissertation significantly enriches the knowledge about the machine learning algorithms operating on small datasets to assist in the diagnosis of eye diseases.

In connection with the above, I conclude that the doctoral dissertation entitled "*Development of machine learning algorithms operating on small datasets to assist in the diagnosis of eye diseases*" fully meets the requirements of the dissertations for the degree of Doctor of Philosophy and I am honored to present to the Scientific Discipline Council of Biomedical Engineering, Wrocław University of Technology (Rada Dyscypliny Naukowej Inżynieria Biomedyczna, Politechnika Wrocławska) an application for accepting this doctoral dissertation thesis and admittance of the mgr inż. Dominika Sułot to the next stages of the doctoral dissertation.



Prof. dr hab. n. med. Andrzej Grzybowski
Chair of the Department of Ophthalmology

WYDZIAŁ LEKARSKI, COLLEGIUM MEDICUM / KATEDRA OKULISTYKI
UNIWERSYTET WARMIŃSKO-MAZURSKI W OLSZTYNIE
Al. Warszawska 30, 10-082 Olsztyn
tel. (89) **524 55 39**
wl.uwm.edu.pl