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REVIEW

Evaluation of the **Ph.D. Thesis** entitled
**"Optimization and Applications of
Extreme Learning Machine Method"**

written by

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Supervisor: Prof. SGGW Ryszard Kozera, D.Sc., Ph.D., M.Sc.

I. Content summary. The work I am evaluating is about improvement of Extreme Learning Machine with optimization and applications. The author has classified his published research papers on ELM into three categories: Python and TensorFlow ELM development, ELM optimization and ELM applications. The content and material sorting is logical and systematic covering the research history of the PhD student. The thesis is divided into six chapters. Chapter 1 is an introduction to the whole work starting with a brief history, the definitions and explanations of Machine Learning and further with its role in AI methodologies. The state of the art related to the dissertation objectives is also given in this chapter after formulating the research problem. Thesis main contributions, as seen by the PhD student, are also discussed. Chapter 2 introduces the author's 9 publications that constitutes the PhD dissertation giving synopsis of the contents of each paper. In chapter 3 we can see the nine papers in their published form. A Conclusion chapter followed by future work description and author's research curriculum vitae are all covered by the last three chapters 4-6.

II. Overall evaluation. The PhD thesis of Mr. Karol Struniawski entitled "*Optimization and Applications of Extreme Learning Machine Method*" deserves the PhD degree. The work, which addresses important problems in the field of artificial intelligence methods is certainly of great interest and covering a relevant literature gap in AI methods. The author has put high efforts in the contribution to the progress and development of the Computer Engineering topics of machine learning, optimization, and practical applications of Extreme Learning Machines. The author has done a good job in presenting the problem through a series of articles published in journals and proceedings of international conferences. In these publications, he suggests successful solutions to

the problems usually existing in Extreme Learning Machine Methods leading to serious modifications of the computational efficiency and parameter optimization.

Therefore, I recommend the PhD work of Mr. Karol Struniawski to be defended without reservation.

III. Student's scientific contribution. I will consider this section with more details and I am classifying it into two main sections – student's scientific achievements and his publications giving at the end some additional scientific activities also related to his doctoral work.

A. Student's achievements. The scientific achievements of the PhD student Karol Struniawski are significant. All present new approaches or serious modifications to the AI methods. Here I will only mention the most important of them.

- Development of an efficient open-source software package (in Python) called TfELM for ELM using CUDA, TensorFlow, and scikit-learn leading to improved performance of the networks.
- ELM Performance Analysis on Apple M-Series Processors leading to comprehensive evaluation of the execution time of ELM and other classifiers on various hardware platforms.
- ELM optimization using Metaheuristics and Activation Function Selection with comprehensive comparative studies of 36 activation functions, including those not previously used in ELM.
- Working out practical applications of ELM such as applying the new approaches to the identification of soil microorganisms and system developing to automate the identification process using ELM and Convolutional Neural Networks.

B. Publications. Karol Struniawski has coauthored 19 publications, three under reviewing and 16 already published as reports, full and regular papers in journals and international conferences. The articles were published in high-scored journals, like Engineering Applications of Artificial Intelligence, Scientific Reports and SoftwareX. The conference papers were published in proceedings of international also known conferences. Nine of the sixteen publications were selected for the dissertation for the PhD degree evaluation, and are related to his main work. He gained a total score of 1790 Polish Ministerial points with a total impact factor of 15.6 and h-index of 3. This is a significant contribution to the state of the art. In his papers, particularly in those, to which I had access, the author has presented his work functionally proving the high efficiency of his methodologies and the approaches he succeeded in working out.

Other scientific activities. The author is active scientifically: he has presented the accepted papers with his work results in eight conferences; he reviewed for more than 20 prestige journals; he has contributed to research collaborations with six scientific institutes from Poland, Italy, Australia and USA. Mr. Karol Struniawski was awarded by the Rector of SGGW for his scientific achievements in 2024.

IV. Comments on the doctoral work. As the work I am evaluating is not exactly a doctoral thesis book, but rather a collection of research already published papers, I will not review them another time - they had already been peer reviewed and accepted. However, I will give my opinion about the organization of the contained matter within the submitted thesis work.

The thesis is well-organized and rich of facilities for good understanding. However, and despite the fact that the author has invested great efforts to clearly present the problem and his approach to

it and its solution, there still are some issues that could have been presented in a more proper and much better way.

a) The work could be written as a complete traditional thesis. All the required aspects are included in his published papers. He would only need to give a short discussion about each part of the work and then include the paper content. This would allow many current and future PhD students and researchers to make use of his achievements presented in a wide knowledge content book rather than searching in journals or conference proceedings.

b) The dissertation title is so general. It does not clearly suggest the author contribution to the problem.

c) The introduction chapter is written very well with clear information whilst the concluding chapter is rather weak and could have been enhanced with more details about the author's work, particularly to contain what was not introduced in the published papers.

d) The methodologies and applications of the student's works are shown in detail in a clear way. However, the used theory and mathematical aspects are rather missing. He would have created a complete reference and source of important achievement about the modified ELM methods side by side with the performance optimization and practical applications, if he had enhanced the work with mathematical approaches. More algorithmic description and proofs could have been added to explain his very good scientific achievements within the area of Machine Learning methodologies, particularly Extreme Learning Machines and their development. This would make the work richer and would enhance the results with solid background. Only a little of that was shown in the work. I am sure the reader would be more satisfied of the whole work if there existed at least a chapter or a section on the algorithmic approaches and mathematical models.

Despite these drawbacks, the content is properly structured and explained. And I would, however, mention here that in no way they have affected the general evaluation, which is very good in my opinion.

V. Concluding Remarks. On the basis of the Computer Engineering knowledge and the engineering contribution the PhD student Mr. Karol Struniawski has shown in his dissertation "*Optimization and Applications of Extreme Learning Machine Method*", the number and quality of his published innovative scientific achievements and results in the area of Computer Science, I conclude that his publications and scientific activities are absolutely sufficient for a PhD degree. Therefore, the evaluated work satisfies the statute and requirements of the Polish Ministry of Science and Higher Education (*art. 190 ust. 2 ustawy z dnia 20 lipca 2018 r. – Prawo o szkolnictwie wyższym i nauce - Dz. U. z 2024 r. poz. 1571, z późn. zm.*) and the student can definitely present his results at the PhD defense.



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