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Review of doctoral dissertation

Anthony Chukwuemeka Nwachukwu, M.Sc.

Entitled

Augmented Lagrangian-Based Algorithms for Separable Non-convex Optimization with Applications in Network Routing and Machine Learning

Implemented in the unit

*Warsaw University of Technology
Faculty of Electronics and Information Technology*

1. The research problem, its solution, and significance

In mathematical terms, the dissertation focuses on non-convex static optimization problems solved using Lagrange multipliers. There are constraints in the form of inequality systems. Importantly, they are separated to a certain extent, the significance of which will be discussed later.

In terms of the IT tools used, numerical methods are applied, importantly, in a parallel and distributed version.

In this context, the development of a new Bertsekas decomposition method is a particularly important added value provided by the doctoral student. From a purely mathematical point of view, the significance of this innovation may be underestimated. However, when combined with a distributed implementation, it fully proves its innovativeness and importance. Namely, it allows for a particularly effective implementation of the constructed optimization method in a parallel version, as it obviously significantly

reduces the need for frequent synchronization of individual computing nodes, where each can, in a sense, autonomously deal with its part of a larger but decomposable optimization problem. Thus, we have the benefits of less frequent data updates and less time spent transferring network data for synchronization in individual nodes.

Chapter 1 precisely formulates the research problem.

Chapter 2 presents the mathematical foundations of calculations in the field of convexity, optimal solution conditions, Lagrange's method, and duality of the problem. It also discusses the convergence conditions of the iterative methods used in the dissertation.

Chapter 3 discusses Lagrange methods in more detail, and in Chapter 4, the doctoral student moves on to separable problems.

In Chapter 4, he independently formulates and develops Bertsekas' asynchronous method.

Chapter 5 applies the developed methods of computational mathematics to the simultaneous routing and bandwidth allocation problem.

Chapter 6 addresses the same technical problem in synchronous and asynchronous versions of the algorithms.

Chapters 7 and 8 apply the developed Lagrange methods to regularized linear systems.

Another technical application is discussed in chapters 9 and 10, namely K-means clustering.

In conclusion, the doctoral student accurately defines the scope of possible applications of his methods and is aware of their limitations. In the summary, he accurately diagnoses open problems. What is more, one of the applications, in network throughput and routability research, has potential for research on the efficiency of parallel and distributed algorithms, in particular those presented in earlier chapters of the thesis, but not only those.

Therefore, the work should be considered thematically coherent, which is not easy to achieve due to its significant interdisciplinary nature.

The above tools and methods are interdisciplinary in nature and cover mathematics, computational informatics (in parallel version), and applications related to technical informatics.

The dissertation is carefully written not only in terms of content, but also in terms of editing. The results obtained are illustrated with numerous one- and two-dimensional graphs and diagrams.

Importantly, the results have been published in two different reputable journals. The choice of journals is relevant to the subject matter of the dissertation, thus providing an additional guarantee that the published results have been competently verified through peer review. The work is interdisciplinary, covering mathematics and computational informatics, and its contribution to the discipline is significant.

In summary, I highly appreciate the innovative level of the work, in particular the development and adaptation of classical mathematical methods in such a way that they are effective in parallel algorithmic implementations without losing or even compromising their accuracy.

Therefore, the work is an example of a successful combination of the results of several disciplines and, thus, interdisciplinary research. Interestingly, the relevance of the selected applications is evidenced by the fact that they have the potential to increase the effectiveness of the theoretical subject matter of the work itself; increasing the efficiency of the network will also increase the efficiency of the implementation itself, which in turn can also be applied to research on further increasing the efficiency of the network. This is a kind of positive feedback in the development of the subject, in the positive sense of the word.

2. Author profile

The doctoral candidate graduated in mathematics from the Federal University of Technology Owerri in Nigeria. He obtained a Master of Science in Nanotechnology from Gdańsk University of Technology. In addition, he obtained a second Master of Science degree in mathematics from the Italian University of L'Aquila. Therefore, the candidate is very well prepared theoretically, and his two master's degrees—one in mathematics and the other in the more physical field of nanotechnology—should be appreciated and complement each other.

He has participated in numerous projects, including fast matrix multiplication, which was achieved using parallel algorithms in Fortran.

The doctoral student also participated in several summer schools in Berlin, Rennes, and Oxford. As can be seen, these include prestigious institutions.

There is no information about the scientific conferences he attended.

His teaching activity is at a good level, which is important as it is consistent with the subject of his work. He taught classes in Numerical Methods and Optimization Techniques.

The author's contribution is confirmed by two publications in reputable journals. Below is an analysis of the candidate's bibliometric data:

According to the Scopus database, the candidate is the co-author of two publications. So far, they have not been independently cited, but they were published very recently, i.e., in 2024 and 2025, respectively. These journals are:

- "*International Journal of Electronics and Telecommunications*" – a journal included in the so-called Philadelphia Journal List. Although it is a national journal published by the Polish Academy of Sciences Committee of Electronics and Telecommunications, with a ministerial score of 70 points, it is indexed by the prestigious Web of Science database in the "Core" collection. In addition, another publication in this journal has been accepted for printing.

- "*Energies*" which is published by MDPI, but has a ministerial score of 140 points and is also indexed by both Scopus and the Core collection of the Web of Science database.

In addition, he is the author of one national publication in the quarterly journal of the TriCity Academic Computer Network Information Center.

The above bibliometric indicators are auxiliary in assessing the Author's achievements. The number of significant publications should be assessed as good at the stage of the scientific career at which the Candidate currently finds himself.

3. Summary

Pursuant to the Act of July 20, 2018, Law on Higher Education and Science (Polish Journal of Laws 2023, item 742), **I hereby declare that the doctoral dissertation submitted by Mr. Anthony Chukwuemeka Nwachukwu meets the requirements for doctoral dissertations in the**

Discipline of science: Information and Communications Technology,

Field of Science: Engineering and Technology,

and I request that it be admitted for public defense.

Jerzy Respondek