

OPINION

by Assoc. Prof. Ivan Georgiev Hristov

Faculty of mathematics and informatics, Sofia university "St. Kliment Ohridski"

on the PhD thesis of

Silvi-Maria Todorova Gurova

entitled

„Stochastic Numerical Methods for Eigenvalue Estimation“

submitted for the acquisition of the educational and scientific degree "Doctor"

under the doctoral program "Mathematical Modeling and Applications of Mathematics"

scientific field 4. "Natural Sciences, Mathematics and Informatics"

professional field 4.5 "Mathematics"

I am a member of the scientific jury for the defense of this PhD thesis appointed by Order № 101 dated 04.05.2026 of the Director of the Institute of Information and Communication Technologies - Bulgarian Academy of Sciences (IICT-BAS), Corresponding Member Sv. Margenov. The jury was approved by the Scientific Council of IICT-BAS dated 29.04.2026 (protocol № 4). According to protocol № 1 of the first meeting of the jury held on 08.05.2026, I have been selected to prepare an opinion. For this purpose, I have received all the documents submitted by the candidate under the procedure.

The opinion has been prepared in accordance with the requirements of the Act on the Development of the Academic Staff in the Republic of Bulgaria, the regulations of its implementation, the BAS regulations, and the regulations on the Specific Conditions for Acquiring Scientific Degrees and for Holding Academic Positions of IICT-BAS.

Relevance of the Topic

The thesis is in the fields of numerical linear algebra and Monte Carlo methods. It deals with the development, justification, analysis, and experimental study of stochastic numerical methods for the approximate finding of the extreme eigenvalues of large symmetric matrices. The considered stochastic numerical methods provide an effective alternative to the traditional direct and iterative methods for very large matrices due to the linear dependence between the dimensionality of the problem and the required memory and also due to the possibility of their parallel implementation on modern computer architectures. Problems related to finding approximate estimates for extreme eigenvalues of large matrices arise, for

example, in the ranking of web pages in Internet search engines, in quantum mechanics, in financial mathematics, and others. So, the relevance of the topic is undeniable and is related to the fact that the development and improvement of algorithms for solving increasingly large problems always stands as a primary task in scientific computing and goes hand in hand with the development of high-performance computing systems.

Structure of the dissertation

The dissertation is presented in a form and volume that meets the requirements. It is written and formatted with care and consists of an introduction, three chapters, a conclusion, an appendix, and a bibliography. The dissertation contains **118** pages, including **15** figures and **16** tables, a bibliography of **121** titles, as well as a list of mathematical notations and abbreviations used.

The **introduction** presents the relevance of the topic, provides an overview, sets the goals and objectives, and describes the research methodology. **Chapter 1** is devoted to the development of efficient stochastic algorithms for finding the largest eigenvalue of dense symmetric matrices based on the Power Monte Carlo and Power Quasi-Monte Carlo methods. **Chapter 2** is devoted to the development of efficient stochastic algorithms for finding the smallest eigenvalue of dense symmetric matrices, using resolvent matrix. The algorithms are based on the Resolvent Monte Carlo and Resolvent Quasi-Monte Carlo methods. In **Chapter 3**, the algorithms developed in Chapter 1 are applied to a practical problem in the field of financial mathematics.

Contributions

The scientific and applied scientific contributions correspond to the successfully implemented goals of the dissertation. They are described in detail in the dissertation and undoubtedly represent an original contribution to science. In general, the contributions consist of the development, justification, analysis, and experimental study of novel stochastic algorithms for estimating the extreme eigenvalues of large symmetric matrices, based on the Power (Resolvent) Monte Carlo and the randomized Power (Resolvent) Quasi-Monte Carlo methods. It is shown that the application of the developed algorithms with a purposeful balancing of the systematic and stochastic error leads to higher accuracy, stability, and computational efficiency. The experimental study used up-to-date high-performance computer systems.

Dissertation publications

The following 4 papers are presented for the dissertation:

1. Gurova, S.-M., Karaivanova, A., Quasi-Monte Carlo Algorithms for Eigenvalue Problems, 4th International Conference Numerical Methods for Scientific Computations and Advanced Applications, NMSCAA'24, 18-22, (2024) (short communication)

<https://parallel.bas.bg/~elilkova/nmscaa24.pdf>

2. Gurova, S.-M., Atanassov, E., Karaivanova, A., A Resolvent Quasi-Monte Carlo Method for Estimating the Minimum Eigenvalues Using the Error Balancing, In: Lirkov, I., Margenov, S. (eds), Large-Scale Scientific Computing, LSSC'23, LNCS, vol. 13952, 394-403, (2024), (SJR:0.352, 2024) https://doi.org/10.1007/978-3-031-56208-2_40

3. Gurova, S.-M., Gurov, T., Karaivanova, A., On the Stochastic Power Algorithms for Estimating the Maximum Eigenvalue of Symmetric Matrices, Contemp. Math., Universal Wiser Publisher Pte. Ltd, 6(5): 7223-49,(2025) <https://doi.org/10.37256/cm.6520257781> (IF:2.5, 2025, WoS: Q1, <https://wos-journal.info/journalid/23187>)

4. Gurova, S.-M., Gurov, T., Karaivanova, A., Eigenvalue Estimation in Portfolio Risk: The Role of Skipping and Leaping in Sobol and Halton Sequences, In: Lirkov, I., Margenov, S. (eds), Large-Scale Scientific Computing, LSSC'25, LNCS, 16061, (accepted)

Paper 1 is published as a scientific communication in a national academic publishing house. Paper 2 is published in Lecture Notes in Computer Science (LNCS) and is indexed in Scopus with c SJR:0.352 (2024). Paper 4 is at present only accepted in LNCS. Paper 3 is published in the journal Contemporary Mathematics and is in Q1 of WoS with IF:2.5 (2024). A total of 70=20+50 points is received from the indicator of group Γ from papers 2 and 3, which is well above the minimum required 30 points.

The results of the dissertation have been reported at numerous representative international conferences in the field, with particularly significant participation in The 15th International Conference on Monte Carlo and Quasi-Monte Carlo methods in Scientific Computing, MCQMC'22, 17-22.07.2022, Linz, Austria, where leading specialists in the field of Monte Carlo and Quasi-Monte Carlo methods gather.

Abstract

In general, the abstract correctly reflects the content of the dissertation.

Critical notes

I have no significant critical notes.

Conclusion

The candidate has demonstrated maturity and solid preparation in many areas of mathematics and computer science. As a result, the dissertation was completed at a high scientific level. The strong results obtained are supported by the rank of the publications presented and the successful participation in prestigious international conferences in the field of the dissertation topic.

The proposed dissertation meets the requirements of the Act on the Development of the Academic Staff in the Republic of Bulgaria, the regulations of its implementation, the BAS regulations, and the regulations on the Specific Conditions for Acquiring Scientific Degrees and for Holding Academic Positions of IICT-BAS.

All of the above provides ample grounds for me to confidently give a **positive evaluation** of the PhD thesis „**Stochastic Numerical Methods for Eigenvalue Estimation**“ and recommend that the Scientific Jury award **Silvi-Maria Todorova Gurova** the educational and scientific degree of “Doctor” in scientific field 4. “Natural Sciences, Mathematics and Informatics”, professional field 4.5 “Mathematics”, under the doctoral program “Mathematical Modeling and Applications of Mathematics”.

01.06.2026

Sofia

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