REFEREE REPORT

by professor Ph.D Nikolai Manev,

The Institute of Mathematics and Informatics – BAS

on the dissertation thesis of **Maria Rumenova Pashinska-Gadzheva** entitled

"Optimization and Paralization of Algorithms Related to Coding Theory"

Submitted for acquiring **"Ph. D. degree**"

Area of Higher Education: **4. Natural Sciences, Mathematics and Informatics**,

Professional Field: **4.6 Informatics and Computer Sciences**

Ph.D. program: **"Informatics"**

Scientific Adviser: **Prof. Dr. Sci. Iliya Bouyukliev**

1. General description of the procedure and the applicant

Maria Pashinska-Gadzheva received Bachelor degree in computer sciences in 2019 at the University of Veliko Tarnovo "St. St. Kiril and Metodi" and MS degree with subject "Mathematical Structures in Information Security" in 2020 at the same university. She started her PhD study in 2021 in the PhD program "Informatics" at the department "Mathematical Foundations of Informatics" of the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences (IMI-BAS). She passed successfully the educational program and according to order No 7 from 02.01.2024 of IMI-BAS has permission to defense her thesis. Since 2019 Maria Pashinska-Gadzheva has been full or part time researcher or assistant professor at the IMI-BAS.

I was appointed to be a member of the Scientific Jury by order No 456/03.12.2024 of Director of the IMI-BAS. In such a capacity I received all required documents (in digital form) that concern the procedure. The documents shows that the applicant fully meets the minimal national requirements according to the Act on Development of the Academic Staff in the Republic of Bulgaria as well as the Regulations for the conditions and rules for acquiring PhD degree of the IMI-BAS.

2. Approbation of the results in the dissertation

The results presented in the dissertation have been described in 6 papers: 5 (P1-P5) are published, and P6 is under review. Maria Pashinska-Gadzheva is the sole author of P2 and P3, while the others are written with her scientific adviser as coauthor. One paper has impact factor (Q1) and anather has SJR (Q2). The rest papers are indexed by MathSciNet, zbMATH, or IEEExplore. Also, 9 talks are given.

The papers have not been used for acquiring other degrees or for occupying positions. The presented results are original and there is no plagiarism.

3. Assessment of the personal contribution of the applicant in joint works

According declaration of coauthors and my discussion with them I can conclude that the personal contribution of Maria Pashinska-Gadzheva to joint papers is equipollent.

4. Impact of the results on the work of other scientists

Maria Pashinska-Gadzheva has reported two citations of her papers although it is not required by the Act on Development of the Academic Staff in the Republic of Bulgaria.

5. Quality of the dissertation Abstract

The Abstract contains 30 pages and presents correctly the content of the chapters and the spirit of the dissertation as a whole. It contains also a summary of main results obtained in the thesis.

6. Description and analysis of results in the thesis

The dissertation thesis contains 102 pages and consists of Introduction, five chapters and Bibliography with 83 titles. The main contributions of Maria Pashinska-Gadzheva are correctly and completely listed at the end of Introduction and on pages 17 and 18 of the English version of Abstract. In my opinion they are solutions of difficult and interesting problems.

Here is a short description of the content of the thesis.

In the Introduction, after remarks on the problems of using computer technology for mathematical research and the place of her research in this area, the dissertation author reviews the contents of each chapter of the dissertation, highlighting the main results presented in each chapter.

Chapter 1 is introductory. It gives the basic concepts and facts of coding theory and parallelization of algorithms. Emphasis is placed on parallelization by vectorization, which is the main method used by the dissertator in her research.

In Chapter 2, Maria Pashinska-Gadzeva presents and comments on the basic algorithms for finding the weight spectrum of a linear code. She divides them into two groups. The first includes the algorithms (referred to as high-level algorithms in the thesis) representing the approach for generating a new codeword and finding its weight. The second group, called low-level algorithms, consists of the algorithms performing the computation. The implementation of the second group is the subject of the dissertation research. It is implemented using extended vector registers for x86 architectures. Optimizations are given depending on the field and the representation of its elements. The performance of the algorithms depending on the compiler and the instructions used in the implementation are also analyzed.

Chapter 3 is devoted to optimization methods for vector addition using unsigned data types. The use of such data, combined with the use of specialized AVX512 instructions for x86 and NEON for ARM, allows efficient implementation for prime fields of up to 128 elements. A comparison of performance using these two instruction families is made as well as a comparison with other instruction families for x86 and with implementations on multiprocessor and multithreaded architectures. The comparisons are presented in tabular and graphical format.

What is presented in Chapter 4 can be defined as an application of the methods developed in the previous chapters to coding theory, more precisely in the study of the class of binary self-complementary codes reaching the Grey-Rankin limit. Six families of parameters of binary two- and three-weight codes reaching the Grey-Rankin bound are considered. The relationships between them are determined and it is shown that codes with such parameters exist and a partial classification of those with dimensions 8 and 9 is made. For two-weight families, a method of constructing codes of dimension k+2 from those of dimension k is proposed. Constructions enabling in the presence of a code from one family to find codes belonging to any of the other families are also proposed.

Chapter 5 presents the **LinCodeWeightInv** software library developed by the dissertator and her supervisor. Its main functionalities, interface functions, and the testing and verification module are described. The main issues in portable software development are also discussed.

Maria Pashinska-Gadzeva's contributions are presented on pages 10 and 11 of the dissertation. After a careful reading of them I can conclude that the author has correctly and comprehensively stated her contributions.

The scientific and applied results obtained in the dissertation are contributions to the solution of difficult and interesting problems concerning the use of modern computer technologies in mathematics. In her research, although it is in the field of software technology, the Maria Pashinska-Gadzeva demonstrates strong mathematical knowledge and obtains mathematical results.

7. Critical remarks

I have no significant critical remarks to the research of Maria Pashinska-Gadzeva and the reviewed dissertation. There are places that need a little better editing, but they are not substantive - omitted/wrong indices and other minor technical errors that do not interfere with the understanding of the exposition.

CONCLUSION

The dissertation thesis of Maria Pashinska-Gadzheva contains theoretical results that are original contribution to the studied area of computer sciences. The thesis fully meets the requirements of the Act on Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its application, and the Regulations for the conditions and rules for acquiring PhD degree of the Institute of Mathematics and Informatics, Bulgarian Academy of Sciences. **She possesses profound knowledge and professional skill in her research area and demonstrates qualities and abilities for carrying out self-depended investigations.**

Based on the aforesaid in this report **I give positive estimation of the considered dissertation and strongly recommend the Scientific Jury to confer Maria Pashinska-Gadzheva the educational and scientific degree ”Doctor” in area of Higher education 4. Natural Sciences, Mathematics, and Informatics**; P**rofessional field: 4.6 Informatics and Computer Sciences; Ph.D. program: “Informatics”.**

15.01.2025 г. Signature:

Sofia Prof. N. L. Manev