Review

Procedure for receiving educational and scientific degree "Doctor" (PhD)

candidate: Paskal Nikolaev Piperkov,
dissertation: "Discrete transforms and their application in coding theory and combinatorics",
Scientific area: 4. Natural Sciences, Mathematics and Informatics,
professional direction: 4.5 Mathematics,
doctor's programme: „Algebra and number theory", department Mathematical Foundations of Informatics, Institute of Mathematics and Informatics (IMI), Bulgarian Academy of Sciences (BAS)

This review is prepared by: prof. dr.sci. Peter Gueorguiev Boyvalenkov, Institute of Mathematics and Informatics, BAS, professional direction 4.5 Mathematics, acting as a member of the Scientific Jury according to Order № 159/27.06.2022 г. of the Director of IMI.

1. **General characterization of the dissertation and the presented materials**
   The presented dissertation contains 97 pages as main content, divided into introduction, 3 chapters and list of references with 71 titles, as well as an author's reference, a list of talks and publications related to the work and a list of citations. These parameters correspond to the commonly accepted minimum requirements of a meaningful dissertation A complete set of the remaining necessary documents is also presented.
2. **Data and personal impressions for the candidate**
   Paskal Piperkov has received MCs degree from Faculty of Mathematics and Informatics of Sofia University "St. Kliment Ohridski" in 1997, speciality Mathematical logic. He was consecutively assistant, senior assistant and professor assistant in Veloko Tarnovo University "St.St. Kiril and Methodius" from 2003 to 2016. Since 2016 г. he is working in IMI-BAS and has been enrolled as external PhD candidate in the doctoral programme "Algebra and number theory" of IMI-BAS on 01.01.2018 with theme "Discrete transforms and their application in coding theory and combinatorics". In this programme he worked on studying discrete transforms and their applications for finding and investigation of parameters of linear codes by using algebraic and combinatorial techniques, including use of computers. This area is relatively typical for the department MFI of IMI and I am familiar with it.

Piperkov has 16 publications, 4 of them related to the dissertation's theme. My personal impressions of the work of Piperkov are very good.

3. Content analysis of the scientific and applied achievements of the candidate from the dissertation and the related publication in the procedure

The results, presented in the dissertation, concern classical problems in Coding theory – determining weight (distance) distribution and covering radius of linear codes. One of the important directions in these investigations is the development and examination of effective algorithms for solving these problems for different classes of parameters. The investigations in the dissertation are focused on the proposed by Karpovsky (about 1980) use of fast discrete transforms, as Walsh-Hadamard (in the binary case), Vilenkin-Chrestensen (for prime finite fields) and transformation of the traces (for composite finite fields) are applied.

In Chapter 1 all necessary for the following exposition notions and results, related to finite fields, traces, linear codes and their parameters and characterizations, discrete transforms of Walsh-Hadamard and Vilenkin-Chrestensen with their basic properties, Kroneker multiplication of matrices and its relation to the fast transforms, and trace transfom, are introduced. The systematic exposition makes good impression. Some of these descriptions are included in the publications related to the dissertation.

Chapter 2 is devoted to the development and investigation of an algorithm for computing the weight distribution of a linear code over a prime field via using a characteristic vector (of a linear code with respect to its generator matrix). Characteristic vector, characteristic distribution and shortened characteristic distribution, whose determination is crucial for the approach, are introduced. The complexity of the proposed algorithms (main and auxiliary) is analyzed and results from numerical experiments are presented, including such for large length codes.

In Chapter 3 methods for computing the weight distribution of linear codes over composite fields are considered. Using a „transition" through the so-called trace code the problem is reduced to the one over a prime field and, correspondingly provides possibility for using the results from Chapter 2. The main result in the chapter is the realization of an approach via transform of traces, which allows the development and analysis of an improved algorithm. The investigation is described in detail and enough examples are provided.

Chapter 4 is devoted to the application of Vilenkin-Chrestensen transform on the characteristic function of a parity check matrix of the corresponding linear code for determining

its covering radius. A similar idea is proposed by Karpovsky for the binary case and the work of the candidate on this problem can be considered as an interesting continuation. In the cases of prime and composite field the obtained results allow the reduction of the covering radius problem to application of the algorithms developed in Chapters 2 and 3.

The results are well described and the required distinction between known results and these obtained by the author (and co-authors) is present. The originality of the obtained results is undoubted and they have deservedly served as a base of already published papers.

4. Approbation of the results

The results from the dissertation are presented at several seminars and international workshops. I was present at a talk by Piperkov several times, including at the National seminar on Coding Theory and can confirm that he explains the material convincingly and with understanding. The publications which form the base of the dissertation are four – one in Cryptography and Communications with impact factor 1.376 (Q2 for Applied Mathematics) and SJR 1.057 (Q1) for 2021 (Chapter 2 is based on this paper), one in each of the proceedings Recent Topics in Differential Geometry and its Related Fields and New Horizons in Differential Geometry and its Related Fields of World Scientific, published in 2019 and 2022, respectively, and in the proceedings of the workshop Optimal codes and related topics, in the frame of Mathematics Days in Sofia, 2017. The co-athors are the supervisor Bouyukliev, Bouyuklieva (in three papers) and Maruta (in one paper), as I find that the contribution of all authors is equal. Three citations are shown in the dissertatation but one of them is in fact auto-citation of a co-author.

These publications cover the minimum national requirements requirements (art. 2b, par. 2 and 3 of LDAPRB) and, correspondingly, the additional requirements of IMI-BAS for receiving the educational and scientific degree “doctor” (PhD) in the scientific area and professional direction of the procedure. The results obtained in the dissertation and the related papers do not repeat similar from previous procedures for scientific degrees and academic positions. The documents presented show that not plagiarism is detected in the dissertation and the related papers.

5. Quality of the abstract

The abstract contains 32 pages and fulfills the requirements for preparation of such documents. The results from the dissertation and its content are correctly presented.

6. Critical remarks and recommendations

I do not have critical remarks apart from some technical grammar mistakes and the mentioned incorrect citation claim. It is natural to recommend to search for other applications (except these for the covering radius) of the techniques developed in Chapters 2 and 3.

7. Conclusion

Having become acquainted with the dissertation presented in the procedure and the accompanying scientific papers and on the basis of the analysis of their importance and the scientific and applied contributions contained therein, I confirm that the dissertation presented and the scientific publications to it, as well as the quality and originality of the results and achievements presented in them, meet the requirements of 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 Ph.D. degree of Institute of Mathematics and Informatics and Bulgarian Academy of Sciences for acquisition by the candidate of the scientific degree "Doctor" in the Scientific area in the Scientific area "Informatics" and, in the Scientific field: 4. Natural Sciences, Mathematics and Informatics, Professional field: 4.5. Mathematics (Algebra and Number theory). In particular, the candidate meets the minimal national requirements in the professional field and no plagiarism has been detected in the scientific papers submitted for the competition.

Based on the above, I recommend the Scientific jury to award Paskal Nikolaev Piperkov the educational and scientific degree „Doctor" in the Scientific field: 4. Natural Sciences, Mathematics and Informatics, Professional field: 4.5. Mathematics.

15.08.2022 г. Prepared by: .....

(prof. dr.sci. Peter Boyvalenkov)