

REVIEW

by

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Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", member of
the Scientific jury (№ ПД 38-84/10.02.2021 г.)

Regarding the application for an academic position "Associate Professor"
in the professional field 4.5 Mathematics (Mathematical Logic)
for the needs of Sofia University "St. Kliment Ohridski" Faculty of Mathematics and
Informatics (FMI), announced in SG no. 105 of 11.12.2020 and on the websites of FMI and
Sofia University

Only **one candidate** has applied for the position --- Chief Assistant Professor Dr. **Stefan Vladimirov Gerdjikov**, Faculty of Mathematics and Informatics, Sofia University "St. Kliment Ohridski", Department of Mathematical Logic and its Applications.

I. General description of the submitted materials

1. Details of the application

The presented documents for participation in the competition are in full accordance with the requirements of the Bulgarian law and the internal regulations of Sofia University. The documents fully comply with the requirements of ZRASRB, PPZRASRB and the Regulations on the terms and conditions for acquiring scientific degrees and holding academic positions at Sofia University "St. Kliment Ohridski" (PURPNSZADSU). These are: curriculum vitae, diploma for higher education, diploma for scientific degree, list of selected and list of all publications, reference for the contributions, reference for the citations, reference for fulfillment of the minimum national requirements under art. 2 b, para. 2 and 3 of ZRASRB, abstracts of the articles in Bulgarian and English and others.

For participation in the competition the candidate Chief Assistant Professor, Dr. Stefan Vladimirov Gerdjikov presented a total of 9 articles, in particular

1. 4 scientific publications with a total IF 6,313, referenced and indexed by the Web of Science,
2. 5 scientific publications in publications with SJR without IF, referenced and indexed by Scopus.

Two of the publications are independent and the others are co-authored. The author has a total of 16 articles. A list of 19 citations of 5 articles of the author is given, and for but the minimum requirements the list is of 17 citations for 4 of the articles (after "doctor").

There are also two other documents from which it can be seen that he was a research supervisor of one and a consultant of two diploma theses for the Master's degree. He was a member of the Program Committee in 2018 and 2020 at the conference Computational Linguistics in Bulgaria.

2. Details of the candidate

Stefan Gerdjikov graduated in Informatics at FMI, Sofia University in 2006, and in 2005-2006 he was a student of Erasmus, majoring in Mathematics at the Technical University of Karlsruhe. In 2008 he became a Master of Informatics, majoring in Logic and Algorithms, at FMI, Sofia University. In the period 2009-2012 he was a graduate student at FMI, SU. In 2014 he defended his dissertation under the supervision of Assoc. Prof. Stoyan Mihov. From 2014 to 2016 he was a Marie-Curie Fellow at the Center for Information and Natural Language Processing, CIS, Ludwig Maximilian University, Germany. From 2007 to 2009 he has been an assistant at FMI, and since 2012 he has been an assistant at the Department of Mathematical Logic, and since 2014 he is a chief assistant at the department. He is a participant in two projects with European funding and in two projects with national funding.

He has received a number of awards and prizes. In 2003 and 2005 he won second place at the Bulgarian National Mathematical Olympiad for students, and in 2003 third prize at the International Mathematical Competition for Students in Romania. In 2004 he received the Order of Kliment Ohridski for achievements in the field of Mathematics, awarded by FMI, Sofia University. In 2013 he won first place at the international scientific competition Scalable String Similarity Search/Join, Genoa, 2013, with the WallBreaker system, jointly developed with Peter Mitankin, Stoyan Mihov and Klaus Schultz. He is the head of the Bulgarian Mathematics Team at the 36th and 37th Balkan Olympiads, and the deputy head of the Bulgarian Mathematics Team at the 61st International Mathematical Olympiad. In this role he gave a series of lectures to the national mathematics team and the Sofia University team.

3. General characteristics of the scientific work and achievements of the candidate

The candidate's scientific work is in the field of the theory of automata and formal languages, which dates back to the mid-20th century. In their classical version, finite state machines are mainly used to recognize whether a word belongs to a given language. Towards the end of the 20th century, interest in them increased and, in addition to recognizers, they were used as transducers. This requires to consider them not only over a finite alphabet, but over the finitely generated monoids, as well as to develop of new algorithms. The aim is to preserve the linear complexity of the automata. Sequential transducers and bimachines provide a natural and effective way to represent functions that transform words into words, into real numbers, or more generally into elements of an arbitrary monoid. Bimachines, composed of two finite deterministic automata and an output function, have the advantage that the regular functions are represented in a deterministic way. Increasing the speed and memory of modern computers leads to an increase in the application of these methods and algorithms in linguistics, speech recognition and synthesis, search and correction of texts and more.

For participation in the competition the candidate Chief Assistant Professor Dr. Stefan Vladimirov Gerdjikov presented a total of 9 articles, including:

(the numbering of the articles is according to the List of selected articles)

- 4 scientific publications with a total IF 6,313, referenced and indexed by the Web of Science, of which
 - two in Q1: [5] Computational Geometry Theory and Applications and [6] Fuzzy Sets and Systems,
 - one in Q2: [7] ACM SIGMOD Record and
 - one in Q4: [3] Theoretical Computer Science

- 5 scientific publications with SJR without IF, referenced and indexed by Scopus, in:
 - Proceedings of the 12th International Conference on Language and Automata Theory and Applications, LATA 2018,
 - Proceedings of the 22nd International Conference on Implementation and Application of Automata, CIAA 2017,
 - Proceedings of the 23rd International Conference on Implementation and Applications of Automata, CIAA 2018,
 - Proceedings of the First International Conference on Digital Access to Textual Cultural Heritage, 2014,
 - Proceedings of the 11th IAPR International Workshop on Document Analysis Systems, DAS 2014.

The scientific works of the candidate fully meet the minimum national requirements (under Art. 2b, para. 2 and 3 of ZRASRB) and respectively the additional requirements of Sofia University “St. Kliment Ohridski” for holding the academic position of “Associate Professor” in the scientific field and professional field of the competition. The scientific publications submitted for participation in the competition do not repeat the ones submitted for obtaining the educational and scientific degree “Doctor”. The author's report accurately reflects the candidate's contributions. No plagiarism was found in the scientific papers submitted at the competition.

3. Characteristics and evaluation of the teaching activity of the candidate

As a student Stefan Gerdjikov has taught seminar sections on “Introduction to Programming”, “Object Oriented Programming”, “Data Structures in Programming” and “Functional Programming”. As an assistant he has taught seminars on all subjects in which the department has classes: “Discrete Mathematics”, “Applications of Finite Automata”, “Discrete Structures 1”, “Discrete Structures 2”, “Languages, Automata and Computability”, “Semantics of Programming Languages”, “Logic Programming”. He is one of the founders of two new elective courses: “Fast Algorithms on Data Structures”, together with Peter Mitankin, and “Machines, Languages, Complexity and Computability”, together with Stefan Vatev. He has taught lectures on “Languages, Automata and Computability”, “Discrete Mathematics”, “Discrete Structures”.

Stefan Gerdjikov is the head of the Master's program “Computational Linguistic” from 2016. In it Gerdjikov has lectures on “Theory of machine learning and some of its applications in neural networks” and “Grammars, Computability and Complexity”.

He was my teaching assistant for the course “Languages, Automata and Computability” for several years and I am impressed by his precision and taste for good difficult problems.

5. Analysis of the scientific and scientific-applied achievements of the candidate, contained in the materials for participation in the competition

Articles can be grouped thematically:

- *Effective algorithms for the construction of bimachines [2,3]*. Gerdjikov and co-authors introduce a new direct algorithm and for the construction of a bimachine from a functional finite transducer, as well as its specialized version, avoiding the preliminary steps for specialized determination and unambiguity. Classes of functional transducers are shown, for which the new design improves the classical one, giving a bimachine with exponentially fewer states. An alternative principle for the construction of bimachines, called the “*principle of accumulation of equalizers*”, is introduced,

which takes into account the various possible paths of the transducer, maximizing the possible output. This leads to a construction in which the space complexity approaches the optimal one. It applies to rational functions from free monoids to “mge-monoids” in a large class of monoids including free monoids, groups, and others, that is closed under Cartesian products.

- ***Axiomatization of monoids [1,4].*** A general class of monoids is defined for which the canonization and minimization of subsequential transducers, with outputs such a monoid, is effectively realizable. Constructive proofs are presented that can be easily converted into algorithms. The class of monoids in question, which includes free monoids, tropical monoids, and groups and is closed with respect to Cartesian product, is described by five axioms. The first four of them correspond to natural algebraic properties from the theory of semigroups, and the latter has been shown to be necessary for canonization to be possible. A class of monoids is considered in which the problem of a sequentialization for functional transducers is decidable by adding three new axioms and the decidability is technically more difficult to prove than in the classical case.
- ***From monoids to maximal factorizations and vice versa [6].*** The property of maximal factorization turns out to be sufficient for many practical problems, such as minimization and canonization. The main connection between the monoids allowing maximal factorization and the monoids with the most general equalizer (mge) was found. Necessary conditions for the existence of maximal factorization are described and necessary conditions are given for an mge-monoid to accept maximal factorization.
- ***Algorithm for minimal pseudo-triangular decomposition of simple polygons [5].*** The article discusses the problem of decomposing a simple polygon into pseudo-triangles and convex polygons with vertices among the vertices of the given polygon. The idea is to decompose the resulting polygon into as few polygons of the considered type as possible. A generalized scheme of dynamic programming from the Keil and Snoeyink algorithm is applied when both convex polygons and pseudo-triangles are allowed. The presented algorithm finds minimal decomposition of a simple polygon with n vertices for $O(n^3)$ time and space.
- ***Effective algorithms for approximate search [7,8,9].*** REBELS and WallBreaker algorithms for hierarchical splitting of a query into subqueries are considered, the solutions of which are combined with the help of effective infix (automatic) structures, the practical effectiveness of which is demonstrated in the articles. WallBreaker solves the classical problem for approximate search with respect to Levenshtein distance. Article [7] considers WallBreaker in the context of other methods and evaluates its empirical effectiveness as the fastest in searching for strings close to a given in large databases. In [8] a new approach to uninformed correction of text is presented, based on automatic extraction of historical patterns by analyzing the structure of words from a historical corpus and comparing it with the structure of the modern dictionary. On this basis, the main generator REBELS, produces candidates for correction even outside the modern dictionary. The article shows a complete system for automatic normalization of historical texts, which basically uses REBELS. The system offers 81.79% accuracy of normalization. The implementation is under the project FP7 CULTURA. A new common and language independent text correction approach, developed and implemented in the framework of the FP7 CULTURA project, based on functional automata, is presented in [9].

From the above it can be seen that the candidate has a number of scientific contributions: a new approach to the generalization of automata; new algorithms based on a new principle for the construction of a b-machine, axiomatization of a general class of monoids; the main connection was found between the monoids, allowing maximal factorization, and the monoids with the most general equalizer; a new algorithm for minimal pseudo-triangular decomposition of simple polygons with cubic time and memory; a new approach to uninformed text correction, as well as very effective applications. The candidate has described the scientific contributions in a peculiar way in the presented reference. He noted exactly what his original contributions were personally. Remarkable is the direct construction from [3], which achieves a number of states of the b-machine $O(2^n)$, obtained by a transducer with n states, improved from $O(n!)$ and the example of a lower limit $O(2^{n/4})$, based on classical ideas and the Dirichlet principle (it is now known that the lower limit is $O(2^{n/2})$). Reading carefully his report on contributions, I came across a surprise reference to a whole 148-page author's monograph "Classical Constructions on Transducers over General Monoids", which examines in detail all the issues and provides full evidence and proofs of the problems in the articles [1-4, 6]. The author's explanation is that the articles [2,3] are conference papers, due to which the results are presented concisely and part of the proofs is missing. This monograph has 7 chapters with three appendices, in which the connection with automata with weights, the maximal factorization and the axioms and the main results are considered. In my opinion, it is worthy of a dissertation for Doctor of Sciences.

One of the articles [7] being cited 24 times. The results were presented at the conferences: 22nd and 23rd, CIAA, 2017, 2018, 11th and 12th International Conference LATA, 2017, 2018, and others.

6. Critical remarks and recommendations

I have no remarks on the merits. It would have been helpful if there were a uniform numbering of the articles submitted for the competition, used in all documents.

7. Personal impressions of the candidate

I have known Stefan Gerdjikov since his student years. I was extremely impressed by his quick mind and sharp thought, he always had an idea of how to find a solution, he solved all the extra credits I gave. Then we became colleagues and my respect for his research and teaching has grown. He has shown great enthusiasm for everything related to the theory of automata and algorithms. It is no coincidence that he made two new courses on fast algorithms and solvability problems and participated in the creation of the master's program "Computational Linguistics", with great care for students. Within this program we already have defended at least 6 theses. As a person he is responsible and modest, which can be seen from the way he approached the aforementioned monograph.

8. Conclusion on the application

After getting acquainted with the materials and scientific works presented in the competition and based on the analysis of their significance and the scientific and scientific-applied contributions contained in them, I **confidently confirm** that the scientific achievements meet the requirements of ZRASRB, the Regulations for its

application and the respective Regulations of Sofia University “St. Kliment Ohridski” for holding the candidate for the academic position “Associate Professor” in the scientific field and professional field of the competition. In particular, the candidate satisfies the minimum national requirements in the professional field and no plagiarism has been established in the scientific papers submitted at the competition. I give **my positive assessment** of the candidacy.

II. OVERALL CONCLUSION

Based on the above, **I confidently recommend** to the scientific jury to propose to the competent authority for the selection of the Faculty of Mathematics and Informatics at Sofia University “St. Kliment Ohridski” to elect Stefan Vladimirov Gerdjikov to take the academic position of Associate Professor in the professional field of 4.5 Mathematics (Mathematical Logic).

01.04. 2021

Referee:

Prof. Dr. Alexandra Soskova