R E V I E W

by Prof. Dr. Vejdi Ismailov Hasanov
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on the materials submitted for participation in a competition
for an occupation of the academic position "Professor"
at the Technical University – Gabrovo

in the field of higher education 4. Natural Sciences, Mathematics and Informatics,
professional field 4.5. Mathematics
scientific specialty Computational Mathematics

In the competition for "Professor", announced in SG no. 50 / 15.06.2021 г. and on the website of Technical University (TU) – Gabrovo for the needs of the department „Mathematics, informatics and natural science" in the faculty "Economics", participates the only candidate Assoc. prof. Dr. Todor Dimitrov Todorov from TU – Gabrovo.

In accordance with order no. 3-01-380 / 24.09.2021 of the Rector of TU - Gabrovo and the decision of the appointed scientific jury I was selected as a reviewer of this competition.

1. Brief biographical data

Assoc. Prof. Dr. Todor Todorov graduated from Plovdiv University "Paisii Hilendarski" in 1986 with a degree in Mathematics with a qualification of "mathematician, mathematics teacher". In the period 1993 – 1997 he was a PhD student at the TU - Gabrovo. In 2001, after successfully defending a dissertation on "Isoparametrics in the finite element method", he acquired the educational and scientific degree "Doctor" (PhD degree) in the scientific specialty "Computational Mathematics".

In the period 1986-1989 he was a teacher of mathematics at the "Maxim Rajkovic" high school. Since 1989, he has been working at the TU - Gabrovo, successively in the years 1987, 2001 and 2006 he held the academic positions of assistant, Ch. assistant and associate professor. Since 2020 he has been the head of the Department of Mathematics, Informatics and Natural Sciences.

2. General description of the presented materials

The set of materials presented by Assoc. Prof. Dr. Todor Dimitrov Todorov is in accordance with the Regulations for acquiring scientific degrees and holding academic positions at the Technical University - Gabrovo. The set includes:
- application for participation in the competition; copy of SG no. 50 with the announcement for the competition; CV in a European model;

- copies of the diploma for completed higher education, the diploma for PhD degree, the certificate from the Higher Attestation Commission for awarding the scientific title "Associate Professor" (holding the academic position "Associate Professor");
- lists of the publications, the citations and the textbooks published for participation in the competition;
- lists of the publications submitted for the acquisition of the PhD degree and for the academic position "Associate Professor"
- copies of the publications;
- author's reference for the contributions in the scientific works; habilitation reference; summaries of the scientific papers (grouped thematically); summaries of the publications in Bulgarian and English
- reference for fulfillment of the minimum national requirements and the requirements of the „Regulations for acquiring scientific degrees and holding academic positions at the Technical University – Gabrovo" for holding the academic position "professor"; information about the impact factor of the journals in which there are publications of the author;
- information for participation and management of scientific projects, with attached contracts; documents for defended doctoral student; a list of journals for which the applicant has received manuscripts for review.

For participation in the competition, Assoc. prof. Dr. Todor Dimitrov Todorov has submitted 34 scientific publications (A29 – A62, according to the numbering of publications in the attached list in the set of documents) after 2007 and 4 textbooks (E1 – E4). Another 26 publications are presented, of which 8 are for the acquisition of PhD degree (A7-A14) and 18 for the academic position of "Associate Professor" (A1 – A4, A6, A15 – A19, A21 – A28). All 34 publications submitted in this competition are in English. There are 9 articles in specialized scientific journals with impact factor, 7 of which are in journals in Q1 (first quartile) (Computers & Mathematics with Applications – A35, A40, A46, A47, Applied Numerical Mathematics – A50, Neural Computing & Applications – A52, Applied Mathematics and Computation – A55) and 2 in Q4 (International Journal of Numerical Methods for Heat & Fluid Flow - A29, Comptes rendus de l'Academie bulgare des Sciences – A49), in journals with impact rank (SJR) are 2 articles (A42, A45), 3 are in conference proceedings referred to in Scopus (A38, A60, A61) and 2 in journals referred to in Zentralblatt Math (A31, A39).

The publication under number A62 in the list is a preprint in the "arXiv" database, which could be missed for the current competition.

The candidate for the competition has attached 4 textbooks - Competitive Mathematics, Further Mathematics – parts I, II and III.

The presented reference in tabular form for the minimum national requirements and those of TU – Gabrovo contains information on a group of indicators for the current competition and for the previous procedures of the candidate – for the educational and

scientific degree "Doctor" and the academic position "Associate Professor". The points for each indicator significantly exceed the requirements and there is no publication to be repeated in two procedures.

3. Impact of the candidate's scientific publications in the scientific community (known citations)

The publications with the participation of Assoc. prof. Dr. Todor Todorov have been cited 67 times according to the presented reference. With the exception of two citing publications, all are after 2007. Of the 67 citations, 23 are in Q1 publications and 13 in Q2. In accordance with the requirements, 312 points have been accumulated for the required 100 points. The presented citations are from 11 publications, as 53 of the citations are from one article. The cited articles are mainly by foreign authors with more than two co-authors and are in renowned international journals. From what has been said, it is clear that the scientific publications and the results of the candidate have received a wide response among the world mathematical community.

4. Survey of the content and results in the presented works

The presented 34 scientific publications in this competition, according to the author's reference, are grouped thematically as follows:

- Conformal methods for dividing a bounded area into multidimensional Euclidean spaces - **A35, A47**, A49, **A50, A55**, A60 and A61;
- Nonlinear nonlocal boundary value problems - A39, **A40**, A42, **A46**, A48, **A52**;
- Linear boundary value problems - A29, A31, A56;
- Quadrature formulas on unstructured networks - A58, A59; A62;
- Theory of finite element networks - A32, A33, A34, A36, A51, A53, A54, A57.
- Numerical analysis of neural networks and voice recognition systems - A37, A38, A41, A43, A44, A45, **A52**.

The publications written in bold above are in authoritative international journals with a high impact factor in Q1. I believe that they contain the main and most significant results in the relevant topic.

The first group of publications on "Conformal methods for dividing a limited area into multidimensional Euclidean spaces" are publications equated to habilitation work, according to Group B of the minimum national requirements in the Regulations for the application of Law for development of the academic staff in the Republic of Bulgaria. With minimum requirements of 100 items, 336 items are accumulated with the presented publications. I note that the candidate in the calculation of points did not include two of the articles with 18 points each. In this group of articles, methods for dividing a bounded region into multidimensional Euclidean spaces are studied. These methods are important in terms of approximate solution and overall computational work. Refinement strategies a three-dimensional network of

simplicial elements have been studied in [A35]. A new refinement strategy, which is optimal concerning in terms of the measure of degeneracy for all canonical domain, is obtained. In [A47], a dissipative algorithm for subdivisions of convex polytopes was developed and applied in four-dimensional Euclidean space. In [A50] the refinement strategy of Edelsbrunner and Grayson (dark red refinement strategy - DRRS) from a computational point of view was studied. A new canonical refinement strategy (CRS) has been obtained, which is better than the previous strategy in terms of the degeneracy measure. With the new strategy, only regular tetrahedrons and canonical simplexes are generated in all levels and for all mixed domains. In addition, unlike DRRS, the new compression strategy does not need an algorithm for proper top node numbering. The paper [A55] is devoted to the properties of some multidimensional simplicial finite elements. New classes of similarity are obtained, which are compared with the Freudenthal's simplicial classes. It has been established that as the dimension of Euclidean spaces increases, so does the measure of degeneracy for each simplicial class. The rate of divergence for all considered sequences of simplicial elements was investigated and it is established that it is characterized by the cosine of the abstract angle between the multidimensional finite element spaces. The hypothesis of Brands et al. concerning the contraction number for the Laplace operator and red refined triangulations of the Freudenthal's elements has been confirmed.

The papers on the subject of "Nonlinear nonlocal boundary value problems" are devoted to elliptical boundary value problems containing a nonlocal term in the strong problem. A general approach in solving the considered equations is to transform the problem into a weak form, to prove the existence of a weak solution, to reduce the problem to an approximate minimization problem. A two-point gradient iterative method [A40, A46] was applied to solve the approximate problem. In [A52] a radially based network method is applied to solve the studied equation. Neural networks were used, and evenly distributed nodes were used for the centers of the radially basic neural network. The presented method by neural networks is an alternative to the finite element method for solving nonlocal boundary value problems in non-Lipschitz areas.

The publications on the subject of "Linear Boundary Value Problems" consider a multigrid finite element method for solving a linear telegraph equation with periodic boundary conditions and the reaction-diffusion equation for calculating the flux across two-dimensional closed Lipschitz- continuous boundary.

Two of the publications on the subject of "Quadrature formulas on unstructured networks" were reported at the National Scientific Conference TechCo 2021 and are included in the collection of reports, and the third is included in the arXiv database.

Most publications on the subject of "Theory of finite element networks" have been reported at national conferences and have been included in the relevant collections or have been published in national journals. In the publications on this subject the problems for triangulation

of the considered areas are investigated. Various techniques have been used to select finite elements in the interior and near the boundary of the area.

The publications on the last subject – "Numerical analysis of neural networks and voice recognition systems", are dedicated to the application of neural networks for solving differential equations and classification of voice signals. The classification of voice signals is extremely important theme for the development of human-machine voice communication. A new stochastic classifier has been obtained for voice control. A successful classification was performed using a new two-layer Boltzmann machine. A finite element classifier has been developed for voice-controlled systems that work with small vocabularies.

The theoretical results in all publications are supported by numerical examples and/or are illustrated with figures.

5. General characteristics of the candidate's activity

5.1. Educational and pedagogical activity (work with students and doctoral students)

Assoc. Prof. Dr. Todor Todorov began his teaching career in 1989, when he began working as an assistant at the Technical University – Gabrovo. He has taught courses in linear algebra, analytical geometry, mathematical analysis parts I and II, numerical methods, selected chapters from higher mathematics, competitive mathematics, higher mathematics parts I, II and III. For the last 4 disciplines Assoc. Prof. Todorov has published textbooks, which are attached to this competition. He is a research supervisor of a successfully defended doctoral student.

5.2. Scientific and scientific-applied activity

The research activity and interests of Assoc. prof. Todorov are in the field of Computational mathematics. One of the main tasks of Computational mathematics is the numerical solution of differential equations – ODEs and PDEs, with initial conditions, with boundary conditions or with mixed conditions. Differential equations are a basic mathematical tool for modelling various real processes and systems, studied in various fields from natural to social sciences, including engineering. For this reason, the interest in studying the properties and methods for solving different types of problems with differential equations continues to grow. One of the main methods for solving boundary value problems for partial differential equations is the finite element method, which belongs to the network methods.

The scientific and scientific-applied results of Assoc. prof. Todorov are related to the application of the finite element method for solving boundary value problems for partial differential equations. The research is on the multi-network finite element method, network selection methods, the properties of the multidimensional finite elements and the application of neural networks for solving differential equations.

Assoc. prof. Todorov has managed 7 research projects with contracts at the TU – Gabrovo. He participated in the development and implementation of a project under the leadership of Prof. Andreev.

Assoc. prof. Todor Todorov is an established scientist in the field of Computational mathematics. Evidence of this are: publications in prestigious scientific journals, of which he is the author or co-author; the invitations for a reviewer from a number of established scientific journals and the abstract Mathematical Reviews; an invitation from the Austrian Science Foundation to review a research project and the remarkable number of citations in peer-reviewed and indexed journals.

6. Scientific and scientific-applied contributions.

The contributions of Assoc. Prof. Todorov in the publications presented in this competition have a scientific and scientifically applied character. The author's reference presents correctly and comprehensively the main contributions, with which I completely agree.

Here are some of the more significant ones in my opinion.

- An algorithm for subdividing of convex polytopes has been developed. In the case of a four-dimensional Euclidean space, it has been shown that each tesseract can be divided into rectangular pentatopes of the same class, and each such pentatope can be divided into rectangular pentatopes of the same class. A new refinement technique into four-dimensional canonical domains have been obtained, which is superior in terms of the measure of degeneracy and the number of similarity classes

- One of the main problems of the finite element method in multidimensional spaces is solved - conformal connection of hypercubic and simplicial networks. All transition elements for each Euclidean space with dimension greater than or equal to three are defined

- When triangulating canonical domains in a n-dimensional Euclidean space, new simplicial classes are obtained. It is proved that the measure of degeneracy for all considered sequences of simplexes increase unlimited when the dimension of space tends to infinity. Analytical relationships were obtained between the studied simplicial classes. Invariant simplexes have been found with respect to different refinement technique.

- New methods have been developed for solving nonlinear nonlocal boundary value problems using neural networks. Neural networks have been constructed to solve nonlinear nonlocal boundary value problems. Numerical methods and algorithms for classification of voice signals have been developed.

7. Assessment of the personal contribution of the candidate

Of the 34 publications submitted in the competition, 9 are independent, of which 4 are in journals with an impact factor, 16 are with two co-authors, 5 – with three co-authors and 4 – with more than three co-authors. The authors of the publications with the participation of Assoc. prof. Todorov have followed the standard for arranging the authors in alphabetical

order. This gives me reason to believe that everyone's participation in the common papers is proportionate.

8. Critical remarks and recommendations

I have no significant critical remarks.

I have indirect information about the work of Assoc. prof. Todorov with the mathematics team of the Technical University - Gabrovo for participation in the National Student Mathematical Olympiad. I have no information about joint publications with students. In this regard, I recommend that, in the future, efforts be made to attract and involve students in research.

9. Personal impressions

I do not have close contacts with Assoc. prof. Todorov, but the few meetings at conferences and the documentation presented in the competition create in me the impression of him as a correct, communicative and well-organized person and scientist.

CONCLUSION:

Given the above, the assessment of the submitted materials and the candidate's contributions, **I strongly recommend Assoc. prof. Dr. Todor Dimitrov Todorov to be elected to the academic position of "Professor"** at the Faculty of Economics of the Technical University – Gabrovo in the field of higher education 4. Natural Sciences, Mathematics and Informatics, professional field 4.5. Mathematics, scientific specialty Computational Mathematics.

28.10.2021   Reviewer: /signature/
                                                                           Prof. Dr. Vejdi Hasanov