**Referee report**

for the academic position of "Professor" in the professional field 4.5. Mathematics, specialty "Computational mathematics", announced in State newspaper no. 21/15.03.2022 for the needs of Department "Scientific Calculations with 3D Digitization and Microstructural Analysis Laboratory", Institute of Information and Communication Technologies, Bulgarian Academy of Sciences

with a single candidate, Assoc. Dr. Stanislav Nikolaev Harizanov

*Reviewer: Prof. Ivan Tomov Dimov - Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences*

The following documents were submitted to the reviewer:

1. CV according to the European model.
2. Copy of diploma for the educational and scientific degree "doctor".
3. Certificate of internship in the specialty.
4. List of scientific publications for the competition, which do not repeat those submitted for the acquisition of the educational and scientific degree "doctor" and for the occupation of the academic position "associate professor".
5. List of citations.
6. Summaries of the scientific publications for participation in the competition - in Bulgarian and English.
8. Certificate of fulfilment of the minimum requirements of IICT.
9. Reference for original scientific and scientific-applied contributions.
10. Declaration that no plagiarism in scientific works has been proven according to the law.
13. Electronic carrier of information according to the requirement of IICT.

## 1. General characteristics of the scientific results

The candidate Assoc. Professor, Dr. Stanislav Harizanov participated in the competition for professor with publications, the list of which includes 17 scientific works, 6 of which have an impact factor; 5 in Q1 and one in Q3, according to Web of Science. 9 articles have an impact rank, one is a chapter of a book, referenced and indexed in the Web of Science and Scopus databases, and one is a teaching aid published in the series "Lectures on Computer Science and Technology of the Institute of Information and Communication Technologies at the Bulgarian Academy of the sciences". 15 of the articles are out, while 2 are in print. All publications are in the period 2019 – 2022, i.e., after his acquisition of the academic position of "associate professor" and were not used in previous procedures.

40 citations of 4 of his works are documented in the applicant's materials. Of these 40 citations, however, only 6 cite one work from the papers submitted for the professorship competition. This is the article:

S. Harizanov, R. Lazarov, S. Margenov, P. Marinov, J. Pasciak. Comparison analysis on two numerical methods for fractional diffusion problems based on rational approximations of t^γ on [0, 1]. In 30th Chemnitz Finite Element Symposium, 2017, LNCSE 128, pp 165–185. Springer, 2019.

These data are either incomplete or testify to a not very good international recognition of the professor candidate. The check I made in the Scopus database showed better results, namely that Prof. Harizanov has 203 citations of his works, of which 118 are with self-citations excluded. It should, however, be the applicant's responsibility to document how many of these citations relate to publications with which the applicant is participating in the competition for professorship. This indicator, in my opinion, largely determines the international recognition of a professor candidate.

The scientific problems considered and the tasks solved by him, in the presented scientific publications, are within the scope of professional direction 4.5. Mathematics, specialty "Computational mathematics".

## 2. Contributions contained in submitted works for review

The applicant's results for the competition are in the areas of numerical analysis, constructive theory of functions, computational complexity of algorithms and analysis of the quality of algorithms.

The results can be conditionally structured in the following directions:

- Effective numerical methods for solving problems with anomalous diffusion.
- Near-optimal numerical algorithms for solving large problems with anomalous diffusion.
- Applications of mathematics in biology.
- Optimization of processes.

In the first scientific direction, new quasi-optimal methods and algorithms have been developed for the numerical solution of problems with a fractional degree of the diffusion operator (in the spectral sense) and homogeneous Dirichlet boundary conditions. They are based on the best uniform rational approximation (BURA) element of the function t^α in the unit interval [0, 1]. In [1], an analysis of the approximation error and also of the properties of the corresponding BURA element in the presence of an additional linear term q was made. It is observed that the error linearly decreases as q linearly increases. In [2] homogeneous boundary conditions of the Neumann type were investigated, and in [7] inhomogeneous Dirichlet boundary conditions for a model one-dimensional problem. In both cases, robust approximation error estimates are obtained. The effectiveness of the proposed methods is illustrated by appropriate numerical

experiments. In [7], the fractional Laplace operator, defined by the integral representation of the Ritz potential, was also investigated. In work [5], a method for solving the classical problem is proposed, in which the BURA element is replaced by a low-rank approximation. This approach is also shown to be applicable to generalized, unstructured spatial discretizations, with an additional contribution of the development being a rank-one version of a diagonal preconditioner that can mitigate the ill-conditioned nature of the extension problem arising under local mesh coarsening as well as singularity of the coefficient. The purpose of this is to improve the performance of the algorithm.

In the second scientific direction, a comparative analysis of the effectiveness of the proposed algorithms compared to other three alternative numerical approaches for solving the task was carried out. All of them are shown to lead to one-dimensional rational approximations, with the BURA approach being the most efficient. A number of numerical experiments are presented (see [4]). An interesting approach is the proposed replacement of the best approximation element with an appropriate approximation element (URA).
In [1] it was noticed that for large values of q and low fractional degree $\alpha$, the derivation of the coefficients and poles in the decomposition of elementary fractions of the BURA element is an unstable computational process, therefore several classes of URA alternatives have been proposed. In [11], two modifications of the BURA algorithm, based on truncation of part of the fractions in the decomposition of the BURA element either as a sum or as a product of elementary fractions, were analysed both theoretically and experimentally. As a result, algorithms with improved computational efficiency have been developed. I think that quite valuable for practical purposes is example 1 from work [11], in which a direct relation is obtained between the order of the poles that can be cut and the condition number of the stiffness matrix for the classical formulation of the problem: a fractional operator of Laplace and homogeneous Dirichlet boundary conditions.

The main contributions in the third scientific direction "Applications of mathematics in biology" include the development of a mathematical model of the dynamics of the spread of COVID-19 in the territory of the Republic of Bulgaria (see work [9]). The model allows prediction of spread dynamics up to two weeks ahead, with errors small for strict measures and larger for relaxed measures. Publication [15] can be considered as a continuation of [9]. In a publication [9], the contribution of vaccination is also taken into account. Thus, in addition to the classic SEIR-model parameters (infection rate, incubation period, recovery time), the new model also contains additional parameters, such as death rate growth, vaccination rate and vaccine efficacy, as well as taking into account the time window needed to the body to build antibodies.
This direction also includes the author's research in the field of analytical anthropology and computer graphics. Currently, these studies are mainly implemented with artificial convolutional neural networks applied to databases of faces and skulls. An important point is the calculation of the distances between the facial and cranial surfaces, represented as a cloud of points. The distance calculation is performed using a projective or Hausdorff metric. It is obvious that in situations where the facial and cranial surfaces have relatively heterogeneous shapes, applying a neural network can cause distortion of the facial region (for example, in the lip region). In order to overcome this problem, in publication [10] a hybrid model for calculating

the skull-skin distances was developed, based on semi-infinite cylinders with a fixed radius r instead of a normal beam. The closest point is the one that first hits the cylinder during its dynamic growth. By varying the value of the parameter r in different cranial regions, a balance between the two metrics is obtained.

In the fourth scientific direction "Optimization of processes" a new class of preconditioners for the interface blocks in solving high-dimensional connected problems is considered, namely, after discretization, the inverse fractional Laplace operator is replaced by its BURA counterpart. It is proved that the considered preconditioners possess optimal computational complexity for the associated discrete problem. The main theoretical contribution is the derived general estimate for the reconditioning number of BURA-based preconditioners, the estimates being completely analogous for positive and negative value of the fractional exponent.

To this direction, the reviewer also refers to a publication [8], in which an experimental comparative analysis of the quality of the parallel implementation of two algorithms for the restoration of digital images contaminated with Poisson noise was carried out. In particular, the scalability of two Poisson image reconstruction algorithms is investigated here. In this case, a hybrid parallelization based on both MPI and OpenMP is used. Experimental results show a substantial improvement in program execution times when testing different image sizes and number of threads used. It cannot be argued that the results are unmatched in terms of parallel acceleration and efficiency for Intel Xeon processors combined with Intel Xeon Phi co-processors. Nevertheless, the achieved results for accelerations for a certain number of processors are quite decent.
The works [6] and [12] consider architectural solutions for optimizing energy management in a building based on the optimal placement of the network infrastructure [6] and a model for early detection of anomalies in the operation of a distributed information system using microservice architectures [12]. The results are interesting, but from the conducted numerical experiments it is clear that in the cascade anomaly detection with "Coarse Sampling" it would be more efficient to apply some variant of sensitivity analysis, where the information obtained through the global sensitivity indices gives more - a complete assessment of the state of the distributed information system.

## 3. Publications and citations of publications participating in the competition.

The relevance and significance of the scientific and scientific-applied contributions are indisputable. They follow from the fact that the majority of publications are in authoritative specialist journals with an impact factor and an SJR index.

Stanislav Harizanov has documented 40 citations of 4 of his works in Scopus/WoS. Of the publications presented for the competition, none is independent, but in this field it is natural to work in groups. At the same time, the candidate's personal involvement does not raise any doubts. In each of the joint works, the candidate has the necessary substantial contribution. Nevertheless, I recommend that in the future the candidate also publishes independent works.

## 4. Educational activity and participation in projects.

Prof. Stanislav Harizanov noted in his resume about guided exercises for university courses at FMI-SU: MA 1-2, DIS 1-2, ODU, UP and OOP. Since 2018, he has been a guest lecturer there and teaches the elective course "Convex Analysis and its Applications in Image Processing".

I did not find any information that Associate Professor Harizanov supervised graduate students. Subsequently, however, I commented on this issue with the candidate and it turned out that under his supervision there is a master's degree, namely Kalin Presnakov, with the topic "Analysis of Neural Rendering methods for solving tasks in computer graphics" (defence is on 12.07.2021 in Sofia, Department of Computer Informatics, FMI). The jury has determined the thesis to be the strongest work during the current session.

There is no record that he was the supervisor of a successfully defended doctoral student.

He is the head of 2 youth scientific projects (to BAS and FNI), one project on fundamental scientific research (FNI) and one bilateral with Austria (FNI).

He is the chairman of the National Commission for 2021/2022 for holding the Mathematics Olympiad, ZMS and PMS for students from 8th to 12th grade at the Ministry of Education and Science. He has been the head of the national school mathematics team since 2019.

There are a number of honors and awards, namely:

- Certificate in the "John Atanasov Award" category, 2017. (for outstanding young Bulgarian scientists in the field of computer science).

- The BAS "Professor Marin Drinov" award for young scientists under 35, 2017. (for scientific achievements in the field of "Information and Communication Sciences and Technologies").

- Diploma for an excellent project under the joint program "supporting young scientists" between MES and BAS, 2017. (in the "Information and Communication Sciences and Technologies" direction for the DFNP-92/04/05.2016 project).

- Elsevier Young Researchers Award - Bulgaria, 2019 (Special Elsevier Prize at the Pythagoras Awards Ceremony).

## 5. Notes and Recommendations.

I have no particular objections to Stanislav Harizanov. My recommendation to the candidate is to more carefully and comprehensively prepare the documents for competitions in order to demonstrate his good international recognition. I have noticed some minor citation and wording inaccuracies in some of the articles. The observed inaccuracies in the least do not diminish the merits of the research of Prof. Harizanov, who is a well-established leading

specialist.

6. **CONCLUSION.** On the basis of what has been highlighted so far, it is clear that the candidate for the announced competition, Assoc. Dr. Stanislav Nikolaev Harizanov, fully meets the requirements of the ZRASRB, the Regulations for the Implementation of the ZRASRB, the Regulations for the Terms and Procedures for Acquiring Scientific Degrees and Holding Academic Positions in the BAS, as well as the Regulations for the specific conditions for acquiring scientific degrees and for holding academic positions at the Institute of Information and Communication Technologies at the Bulgarian Academy of Sciences. The achieved scientific results give me the reason to propose that the candidate Assoc. Dr. Stanislav Nikolaev Harizanov be elected as a professor at IICT-BAS in professional direction 4.5. Mathematics, special "Computational mathematics", announced in SG no. 21/15/03/2022 for the needs of the "Scientific calculations with Laboratory of 3D digitization and microstructural analysis" section

**For this reason, my conclusion on the occupation of the academic position "Professor" announced by the competition by Ass. Prof. Dr. Stanislav Nikolaev Harizanov is POSITIVE.**

На основание
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