

## Review

under a procedure for defence of a doctoral dissertation entitled:

### **Neural Networks for Facility Location Problems**

for the acquisition of PhD degree

candidate: **Vladislav Valeriev Haralampiev**

Field of higher education: 4. Natural sciences, mathematics and informatics

Professional direction: 4.6. Informatics and Computer Science

Doctoral Program: „Computer Science“ – Algorithms and Complexity,

Department: "Mathematical Logic and Its Applications" Faculty of Mathematics and Informatics (FMI), Sofia University "St. Kliment Ohridski" (SU).

The opinion was prepared by: Prof. Dr. Nicola Ivanov Yanev, retired

in my capacity as a member of the scientific jury, according to Order No RD 38-292/2.07.2021 Rector of Sofia University.

1. General characteristics of the dissertation work and the materials presented

The dissertation work has a volume of 180 pages: 5 chapters, conclusion, two appendices and a list of quoted literature. Bibliography is 107 titles.

2. CV and personal impressions of the applicant

Education:

2017 – 2021

Sofia University " Kliment Ohridski" Faculty of Mathematics and Informatics "

PhD Student Professional Direction 4.6.Informatics and Computer Science

Doctoral Program: "Computer Science" — Algorithms and Complexity

2015 - 2017

Sofia University " Kliment Ohridski" Faculty of Mathematics and Informatics "

Master, Artificial Intelligence Success: 6.00, graduated with full distinction

2011 - 2015

Sofia University „Faculty of Mathematics and Informatics“ Bachelor, Computer Science Success: 6.00, graduated with full distinction

2003 - 2011 Sofia Mathematical High School (SMG) success 6.00

### Awards and Scholarships

#### As a student

- In 2014 he was selected Student of the Year by the Ministry of education and science.
- Sofia University Student of the Year Award 2015 – 2016 and winner in the category "Mathematics and Informatics".
- In 2014, he received an award from the FMI-Society Foundation in memory of Prof. Dr.Sc.(Econ.) Ivan Soskov for research achievements in the field of computer science.
- In 2013 and 2015, awarded a certificate of scientific excellence by the The Rector of the University of S.C.
- In 2016-2017, he was awarded a special scholarship by Huawei Technologies for achievements in computer science.

In 2011, 2012, 2015 and 2016, a Fellow of the Eureka Foundation for international Olympiad in Informatics.

- In 2013 and 2014, awarded by the Eureka Foundation with a named computer science scholarship in the name of "John Atanasov".
- Programming competitions (only part of them)

#### As a student

Between 2011 and 2015 captain of the team of Sofia University of Competitions programming systems. Participated in many competitions, follow the most important of them, qualified (individually or in a team) for the finals.

- International competitions

- Deadline24 2018 (Final)

7 - 8 April 2018, Katowice, Poland.

- VK CUP 2016 (Final)

• 1 - 4 July 2016, Saint Petersburg, Russia.

- Challenge24 (Final) in Budapest, Hungary.

He participated three times, in 2014, 2015 and 2016.

- ACM SEERC (Southeastern Europe Regional Contest) in Bucharest, Romania

He has participated four times, in 2011, 2012, 2013 and 2014.

- Russian Code Cup

September 2013, Moscow, Russia.

- Microsoft Bubble Cup in Belgrade, Serbia

He participated three times, in 2011, 2012 and 2013.

- Traineeships:

Software Engineering Intern Google, Inc Intern in the office in Mountain View, California, USA

Team: Engineering – YouTube Ads July 2019 – September 2019 and July 2018 – September 2018 and July 2017 – October 2017 July 2016 – October 2016 and July 2015 – October 2015

The dissertation explores the potential of neural networks to solve combinatorial optimization problems. A new heuristic-based neural networks has been proposed. Heuristics are described in the context of so-called facility location problems. Asymptotic convergence to the optimal solution has been proven with a proposal for speed assessment. Results for a comprehensive (too long) application of the heuristic to test examples from 6 classes of optimization problems (small size) called briefly (and in detail defined): p-MiniSum, p-Hub, p-DefenseSum, MaximalCovering Location Problem, Flow Intercepting Facility Location ,Assignment problem , is given.

To the contributions we should add the overview part with included analysis of known neural networks with a comment on their ineffectiveness in solving mathematical optimization problems, not least the generation of test examples for

each of the above 6 classes and the creation of appropriate (for the heuristic) boolean models of non-linear optimization.

The dissertation is based on the following publications:

V. Haralampiev. Theoretical Justification of a Neural Network Approach to Combinatorial Optimization: Proceedings of the 21st International Conference on Computer Systems and Technologies. 2020.

V. Haralampiev. Neural network approaches for a facility location problem , International Scientific Journal Mathematical Modeling. 2020.

V. Haralampiev. Single facility location problems in k-trees: 58th Annual Science Conference of Ruse University and Union of Scientists - Ruse. 2019.

V. Haralampiev. Neural networks for facility location problems , Annual of Sofia University St. Kliment Ohridski. 2019.

V. Haralampiev. Dynamic facility location problems , Young Researchers Conference proceedings 2019.

**I don't know any citations or impact factors.**

Approbation of results

-the scientific works meet the minimum national requirements (under Art. 2b, para 2 and 3 of the IRASBR) and respectively the additional requirements of "St. Kliment Ohridski" University for the acquisition of educational and scientific degree "Doctor" in the scientific and professional direction of the procedure;

-the results presented by the applicant in the dissertation and scientific papers thereto do not repeat those of previous procedures for obtaining a scientific title and academic position;

-there is no statutory plagiarism in the dissertation and scientific papers presented under this procedure.

1. Qualities of the abstract

The abstract meets all the requirements for its preparation and presents correctly the results and content of the dissertation.

## Remarks

A heuristic algorithm is presented to find an extreme vertex of an n-dimensional unit hypercube, the coordinates of which are arguments of a function (nonlinear). To escape a local extremum, the walk is perturbed by a stochastic element similar to the one used in the **simulated annealing** heuristic. Some of the vertices are feasible solutions of a nonlinear boolean optimization problem with feasible points - 0/1 solutions of a system of equations, which in the terminology of the integer optimization are known as SOS (special ordered set) modeling choose of exactly one element of k. Of the problems solved in the dissertation (known as location – allocation problems, plant (facility) location), only the assignment problem (AP)) has such a feasible set, but even it requires the construction of a specific mathematical model (SMM) substantially different from linear 0-1 models that allow the use of available software (CPLEX, GUROBI, etc.). The creation of such a model (SMM) for the purpose of using the proposed heuristic is a separate research task and can significantly affect its usage beyond those already built by the author. Another feature of the SMM is that the feasibility of the generated points in relation to the original problem, is guaranteed (without proof) only for the optimal points. For the only "easy" of the problems solved in the dissertation, namely AP e.g. the feasible solutions of SMM are 0-1 row stochastic matrices, of which only part are double stochastic (AP feasible). This suggests inclusion in the heuristic performance analysis- reaching an optimality in acceptable time, whether the record by value of the objective function is reached at a feasible point.

### •3. Conclusion

Having become acquainted with the dissertation work presented in the procedure and the scientific papers submitted to it and on the basis of the analysis of their significance and the scientific and applied contributions contained therein, I **confirm** that the thesis submitted and the scientific publications thereto, as well as the quality and originality of the results and achievements presented therein, meet the requirements of the ЗАРАСБ , its Implementing Regulations and the relevant Regulations of SU "St Kliment Ohridski" for the acquisition by the candidate of the educational and scientific degree "Doctor" in the scientific field

4. Science, Mathematics and Informatics and Professional direction 4.6.  
Informatics and Computer Science.

In particular, the applicant **satisfies the minimum national requirements** in the professional field and plagiarism has not been established in the scientific papers submitted under the competition.

On the basis of the above, I recommend to the scientific jury to award **Vladislav Valeriev Haralampiev** an educational and scientific degree "Doctor" in scientific field Natural Sciences, Mathematics and Informatics, professional direction 4.6. Informatics and Computer Science.

27.08.2021

Reviewer: .....

prof. Nicola Yanev