O P I N I O N

on a Ph.D. Thesis

“Neural Networks for Facility Location Problems”

presented by Vladislav Valeriev Haralampiev

for acquiring of the educational and scientific degree "Doctor"

in Professional field 4.6. Informatics and computer science,

Doctoral program "Computer Science – Algorithms and Complexity"

Member of the Scientific juri:

Prof. DSc Stoyan Nedkov Kapralov, Technical University – Gabrovo

The opinion was prepared on the basis of an Order of the Rector of Sofia University № RD 38-292 / 02.07.2021 and a decision of the first meeting of the scientific jury, held on 05.07.2021.

1. Data on doctoral studies, dissertation, thesis summary and publications

This procedure is conducted in accordance with the Regulations on the terms and conditions for acquiring scientific degrees and holding academic positions at Sofia University “St. Kliment Ohridski”.

Vladislav Haralampiev was a full-time doctoral student at the Department of Computer Informatics at FMI from 10.07.2017 to 10.07.2020 with supervisor Assoc. Prof. Dr. Minko Markov. He was exmatriculated with the right to thesis defense.

The dissertation has a total volume of 180 pages and is written in English. It consists of five chapters.

The research in the dissertation is dedicated to problems related to combinatorial optimization. A new type of neural network has been proposed - Competition-Based Neural Network, which perfectly solves a number of classical optimization problems for object placement.

Chapter 1 is introductory and has an overview. Six classic combinatorial tasks for object placement are presented.

Chapter 2 presents eight popular metaheuristics for combinatorial optimization. The application of two types of neural networks for combinatorial optimization is also considered.

Chapter 3 introduces networks with competing neurons. A generalized task for object placement is defined. The idea of optimization with competing neurons is attached to this task. The

obtained algorithm is written in the form of a pseudocode (on page 61 in the dissertation) and is compared with the known metaheuristics for combinatorial optimization.

Chapter 4 is devoted to the study of the properties of networks with competing neurons. It is theoretically justified why they can be expected to find a good solution. Two interpretations of the sequences of states of individual neurons are considered.

Section 4.1 empirically discusses the behavior of the neural network in solving optimization problems. Section 4.2 demonstrates a number of network properties observed in the empirical study. Asymptotic convergence was demonstrated in 4.4, and convergence rate was investigated in 4.5. Section 4.6 analyzes the relationship between the quality of the solution found and the mechanism for lowering the temperature of the neural network.

In Chapter 5, competing neuron networks are applied to six specific object placement tasks: p-MiniSum, p-Hub, p-Defense-Sum, Maximal Covering Location Problem, Flow Intercepting Facility Location, Assignment Problem.

Networks with competing neurons do well with test cases. Solutions close to the optimal ones are found for all input data. In some cases, even optimal results are achieved.

Vladislav Haralampiev has five publications on his dissertation. One of these publications is visible in Scopus. One is in a scientific journal, the others are reports at scientific conferences. All publications are by one author and are written in English.

The abstract is prepared according to the requirements and correctly reflects the content of the dissertation.

2. Scientific contributions

The contributions of the dissertation are scientific and scientific-applied.

3. Remarks on the dissertation

I have no remarks on the dissertation.

4. Conclusion

I believe that **the presented dissertation fully meets the requirements** of the Academic Staff Development Act in the Republic of Bulgaria, the Regulations for its application and the Regulations on the terms and conditions for acquiring scientific degrees and holding academic positions at Sofia University "St. Kliment Ohridski ”.

The dissertation contains scientific results, which represent an original contribution to science. The candidate has in-depth theoretical knowledge and abilities for independent research.

I assess positively the presented Ph.D. thesis and the achieved results give me grounds to **convincedly propose** to award the educational and scientific degree "Doctor"to Vladislav Valeriev Haralampiev in Professional field: 4.6. Informatics and computer science.

26.08.2021 г. **Member of the juri:**

Gabrovo /Prof. DSc Stoyan Kapralov/