

## CV of Dr. Tatjana Davidović

### Research Professor

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### Short bio

Dr. Davidović received her B.Sc. degree at Faculty of Mathematics, University of Belgrade, in 1987. and M.Sc. degree at the same faculty, in 1992, with the thesis *An Approach to Parallelization of Symbolic Robot Model*. In 2006 she obtained PhD degree at Faculty of Mathematics, University of Belgrade with the thesis *Scheduling Tasks to Multiprocessor Systems by Applying Metaheuristics* under the supervision of Professors Nenad Mladenović and Dušan Tošić. She is engaged in doctoral courses on Parallel Programming, Metaheuristics, and Optimization at the Faculty of Technical Sciences, University of Novi Sad, Serbia. Dr. Davidović participated in a number of national and international scientific projects, 4 of them as leader. Her main research interests include parallel computing, scheduling, combinatorial optimization, mathematical programming, metaheuristics. She has published 4 chapters in international monographs, 31 papers in refereed international journals, more than 70 papers in conference proceedings and she delivered three invited talks at the international conferences. She is a member of the Editorial Board of two scientific journals and Program Committees for several international conferences related to optimization, computer science and information technology fields. Dr. Davidović is a Deputy Chair of the Computer Science and Applied Mathematics Colloquium (weekly meetings with distinguished national and foreign lecturers) and a member of the Serbian Scientific Society. According to SCOPUS database, her results were cited (excluding self-citations) 427 times and her Hirsch index is 10 (May 2023).

### Relevant publications

1. Maleš, U., Ramljak, D., Jakšić-Krüger, T., **Davidović, T.**, Ostojić, D., Haridas, A., [Controlling the Difficulty of Combinatorial Optimization Problems for Fair Proof-of-Useful-Work based Blockchain Consensus Protocol](#), *Symmetry*, Special Issue "Advances in Multidisciplinary Exploration for Symmetric Key Cryptography and Blockchain Technology", 15(1), pp. 140:1-32, 2023.
2. Matijević, L., Jelić, S., **Davidović, T.**, [General Variable Neighborhood Search Approach to Group Steiner Tree Problem](#), *Optimization Letters*, Special Issue dedicated to ICVNS 2021 virtual conference, 2022. DOI: 10.1007/s11590-022-01904-7
3. Teodorović, D., **Davidović, T.**, Tselimi, M., Nikolić, M., [Bee Colony Optimization and its Applications](#), in Kulkarni A., Siarry, P. (Eds.) *Handbook of AI-based Metaheuristics*, CRC Press, Boca Raton, pp. 301-321, 2021.
4. Anokić, A., Stanimirović, Z., **Davidović, T.**, Stakić, M., [Variable neighborhood search based approaches to a vehicle scheduling problem in agriculture](#), *International Transactions in Operational Research*, 27(1), pp. 26-56, 2020.
5. **Davidović, T.**, Jakšić-Krüger, T., [Convergence Analysis of Swarm Intelligence Meta-heuristic Methods](#), In: Ereemeev A., Khachay M., Kochetov Y., Pardalos P. (eds.), *Proc. OPTA 2018*, Omsk, Russia, July 08-14, 2018, (CCIS, volume 871), Springer, 2018, pp. 251-266.
6. Kovačević, N., **Davidović, T.**, Stanimirović, Z., [Variable neighborhood search methods for the dynamic minimum cost hybrid berth allocation problem](#), *Information Technology and Control*, 47(3), pp. 471-488, 2018.
7. **Davidović, T.**, Teodorović, D., Tselimi, M., [Bee Colony Optimization Part I: The Algorithm Overview](#), *YUJOR*, 25(1), 33-56, 2015.
8. Teodorović, D., Tselimi, M., **Davidović, T.**, [Bee Colony Optimization Part II: The Applications Survey](#), *YUJOR*, 25(2), pp. 185-219, 2015.
9. Stojanović, T., **Davidović, T.**, Ognjanović, Z., [Bee Colony Optimization for the Satisfiability Problem in Probabilistic Logic](#), *Appl. Soft Comput.*, 31, pp. 339-347, 2015.
10. Crainic, T. G., **Davidović, T.**, Ramljak, D., [DESIGNING PARALLEL META-HEURISTIC METHODS](#), In *High Performance and Cloud Computing in Science and Education*, Despotović-Zrakić, M., Milutinović, V., Belić, A., (eds.), IGI-Global, pp. 260-280, 2014.

## Research Group

Mathematical Programming and Optimization research group in the Mathematical Institute of the Serbian Academy of Sciences and Arts consists of 2 senior researchers, 3 young researchers and 4 PhD students. The research activities involve also external collaborators from several Serbian universities and some foreign institutions at all five continents. The main research topics include developing mathematical models and methods for various optimization problems. Among considered optimization problems the special attention is paid to optimization on graphs, scheduling, transportation, location, etc. We also work on real-life optimization problems raising in science and industry. We apply different general purpose exact solution packages (CPLEX, Gurobi, LINGO, etc.) and develop problem specific exact and heuristic algorithms. Although working with various metaheuristic methods, we particularly promote the ones developed by Serbian researchers, Variable Neighborhood Search (VNS) and Bee Colony Optimization (BCO). Parallelization, theoretical and empirical evaluation of metaheuristics are also in the focus of our research.

Current research trends in our field propagate the integration of Artificial Intelligence (AI) and optimization methods. Therefore, we established a project called Integrating Machine Learning and metaheuristics that completely follows this concept.

In the year 2020, Mathematical Institute established a Research Internship for (Under)Graduate Students from Serbia and abroad. The Institute provides working space, hardware and software resources, and supervisors for the selected research topics. However it cannot offer any kind of financial support for students. Our research group successfully supervised 11 candidates, 5 of them published conference papers, while two candidates co-authored one journal article. More details about the Research Internship related to the development of metaheuristic algorithms for optimization problems can be found at <http://www.mi.sanu.ac.rs/~tanjad/ResearchInternship.htm>.

## Work Proposal

The award winning candidate will work with other students at MISANU on integrating Machine Learning (ML) and metaheuristics (MH). This research project involves two potentially overlapping parts: Applying ML to improve performance of MH methods and increasing the efficiency of ML by the application of MH. We are specifically interested in the Bee Colony Optimization method (BCO) and Variable Neighborhood Search (VNS). BCO and VNS are promising MH methods for designing powerful and efficient heuristic algorithms tailored to deal with many considered classes of optimization problems.

Our objective related to the first part of the project is to incorporate ML techniques into the development of the BCO (VNS) algorithm. More precisely, we want to apply ML for tuning parameters of the BCO (VNS) MH method. The concrete optimization problem will be selected jointly with the potential candidate. The classical off-line techniques for fine-tuning of the BCO (VNS) parameters are impractical and time consuming processes. Some alternatives, automatic parameter tuning software, applying fuzzy systems, etc., exist in the literature, however, more sophisticated approaches are required in order to ensure that BCO (VNS) performance is comparative (or even better) compared to other MH methods. We believe that ML techniques for BCO (VNS) parameter calibration could significantly contribute to robustness, effectiveness and efficiency of the resulting optimization method.

Another possible line of research within the first part of the project would be to apply ML techniques to ensure better convergence properties of BCO (VNS). It has been demonstrated that BCO satisfies requirements of the model-based convergence, while for VNS only best-so-far convergence is proven, both in the theoretical sense. However, the practical exploitation of this fact is still limited due to the slow convergence rate. Theoretical analysis has shown that BCO needs to learn from previously visited solutions and to adjust solution transformation rules (more precisely, selection probability of possible transformations) according to the gained knowledge. However, the adjustment rule based on pure theoretical considerations ensures asymptotic convergence which is inapplicable in practice. Therefore, we aim to examine the application of statistical learning as well as ML techniques to define the adaptation of selection probabilities such that the BCO convergence rate increases. For VNS it is first needed to establish the model-convergence requirements and then to apply similar approach to improving the practical usefulness of the resulting VNS-based optimization algorithm.

Within the second part, objective could be to incorporate the BCO method into the ML techniques. A typical line of research involves using BCO for tuning of (hyper)parameters of some ML algorithms, for example, for training of artificial neural network (ANN). Calculating appropriate values for weighting coefficients of ANN can be formulated as an continuous optimization problem. The objective function is defined as the prediction error, i.e., the difference between the outputs provided by the trained ANN and the ones given as the labels in the instances from the training set. The goal of optimization is to find the weighting coefficients values that minimize this error. Classical training methods are time consuming, especially for the complex ANN or Deep Neural Networks (DMM) with multiple hidden layers. Several recent studies are reporting promising results in the application of various MH methods to ANN training. Especially population-based methods proved their efficiency in this domain. Therefore, we believe that BCO has potential to exhibit good performance when dealing with this task.

### **Other Information**

The **Mathematical Institute of the Serbian Academy of Sciences and Arts (MISANU)**, (<http://www.mi.sanu.ac.rs/>) was founded in 1946 as the first institute of the Academy. For many decades MISANU is the unique center for mathematically-oriented fundamental and technological research in Serbia, employing more than 70 full-time researchers. Recognizing its importance, Government of Serbia declared MISANU as National Institute of the Republic of Serbia in April 2021. MISANU is an institutional member of the European Mathematical Society. According to the Webometrics Ranking, <http://research.webometrics.info/en>, MISANU is the most influential Serbian institute at Internet. MISANU has a number of experts performing high-quality research in several areas of mathematics, mechanics, and computer sciences. The strongest research groups within MISANU (which are also the most internationally recognized: see, for example, <https://www.scimagojr.com>) are in mathematical logic and discrete mathematics (optimization, cryptology). Among other fields of research, geometry, operator theory, and analysis are the most influential ones. As the service center for all Serbian mathematicians, MISANU has the largest library with books and journals in mathematics, computer science, physics and other relevant fields. High Performance Computing (HPC) laboratory contains two IBM clusters, several servers and the largest data flow Field-Programmable Gate Array (FPGA) board (developed by Maxeller Technologies) in the South Europe.

**Belgrade** is a capital of Serbia, situated at a joint of two large rivers Sava and Danube with many green surfaces and parks. It is a very dynamic city that never sleeps and has a lot of attractions for young people. It is known by many festivals, theatres, museums, restaurants. The Institute is located downtown city in the pedestrian street, in the vicinity of numerous cultural and amusement places.

**Accommodation** in Belgrade is not too expensive and it will be easy to find something suitable for potential student that awarded SPECIES scholarship. MISANU does not have any special accommodation for visitors or students, however, depending on the time of visit, we may use a room in the student residence.

Unfortunately, there is a small chance for providing **additional financing** for the award winning candidate. On the other hand, having in mind the live expenses in Serbia, the funds provided as SPECIES scholarship may cover the extension of one or even two months.