CV of Dr. Tatjana Davidović

Research Professor
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Senior Lecturer
Faculty of Technical Sciences, University of Novi Sad, Serbia
(Doctoral courses on Parallel Programming, Metaheuristics, and Optimization)

Education:
Ph.D. degree in 2006 at Faculty of Mathematics, University of Belgrade, thesis: *Scheduling Tasks to Multiprocessor Systems by Applying Metaheuristics* (supervisors Professors Nenad Mladenović and Dušan Tošić.

Research interests:
My research interests include parallel computing, scheduling, combinatorial optimization, mathematical programming, metaheuristics. I have published 3 chapters in international monographs, 25 papers in refereed international journals, more than 50 papers in conference proceedings and delivered three invited talks at the international conferences.

Research projects:
Graph theory and mathematical programming with applications to chemistry and computer science (2011-2019);
The Development of Hybrid Heuristics for Combinatorial Optimization Problems, bilateral cooperation between Serbia and France (2016-2017)

Relevant publications

1. **Davidović, T.**, Jakšić Kruger, T., Convergence Analysis of Swarm Intelligence Meta-heuristic Methods, In: Eremeev A., Khachay M., Kochetov Y., Pardalos P. (eds.), *Proc. The 7th International Conference on Optimization Problems and Their Applications*, OPTA 2018, Omsk, Russia, July 08-14, 2018, (CCIS, volume 871), Springer, 2018, pp. 251-266.
2. **Davidović, T.**, Glišović, N., Rašković, M., Bee Colony Optimization for Clustering Incomplete Data, In: S. Belim et al. (eds.): *Proc. The 7th International Conference on Optimization Problems and Their Applications*, OPTA 2018, Omsk, Russia, July 08-14, 2018, (OPTA-SCL 2018), CEUR Workshop Proceedings, 2018, pp. 94-108.
3. Jakšić Kruger, T., **Davidović, T.**, Teodorović, D., Šelmić, M., The Bee Colony Optimization Algorithm and its Convergence, *Int. J. Bio-Inspired Computation* 8(5), 340-354, 2016.
4. **Davidović, T.**, Teodorović, D., Šelmić, M., Bee Colony Optimization Part I: The Algorithm Overview, *YUJOR*, 25(1), 33-56, 2015.
5. Stojanović, T., **Davidović, T.**, Ognjanović, Z., Bee Colony Optimization for the Satisfiability Problem in Probabilistic Logic, *Appl. Soft Comput.*, 31, pp. 339-347, 2015.
6. 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.
7. **Davidović, T.**, Jakšić, T., Ramljak, D., Šelmić, M., Teodorović, D., MPI Parallelization Strategies for Bee Colony Optimization, *Optimization*, Special Issue entitled "Advances in Discrete Optimization", dedicated to BALCOR 2011, 62(8), 1113-1142, 2013.
8. Maksimović, P., **Davidović, T.**, Parameter Calibration in the Bee Colony Optimization Algorithm, in Proc. *11th Balkan Conf. on Operational Research*, BALCOR 2013, Beograd-Zlatibor, Sept. 07-11, 2013, pp. 255-264.
9. **Davidović, T.**, Ramljak, D., Šelmić, M., Teodorović, D., Bee Colony Optimization for the *p*-Center Problem, *Comput. Oper. Res.*, 38(10), pp. 1367-1376, 2011.

Research Group

The core of our research group combines talents of 4 senior researchers and 3 graduate students at the Mathematical Institute. The group also involves external collaborators from several Serbian universities and some foreign institutions. The main research topics are directed towards the development of mathematical models and (meta)heuristic optimization methods for various world-known optimization problems. We apply different general purpose exact solution methods (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).

Current research project investigates parallelization, theoretical and empirical evaluation of metaheuristics. Among considered optimization problems the special attention is paid to optimization on graphs, scheduling, transportation, location, etc. Our interest is also directed towards the integration of Artificial Intelligence (AI) and optimization methods to deal with real-life optimization problems that occur in science and industry. Therefore, we have initialized a project called **Integrating Machine Learning and Metaheuristics** that completely follows this concept.

Graduate students at our Institute and within our research group had followed different academic paths, such as studies in Mathematics, Computer Science, Electrical Engineering, Astronomy and Mechanical Engineering. The working conditions and atmosphere is, thus, very receptive and we aim to provide an environment that is helpful, vibrant, and innovative.

Work Proposal

The award winning candidate will work with other students at MISANU on integrating Machine Learning (ML) and metaheuristics (MH). This research project consists of two parts: Applying ML to improving 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). BCO is a promising MH method for designing powerful and efficient heuristic algorithms tailored to deal with the considered class of optimization problems.

Our objective related to the first part of the project is to incorporate ML techniques into the development of the BCO algorithm. More precisely, we want to apply ML for tuning parameters of the BCO 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 parameters are time consuming processes. Some alternatives, applying fuzzy systems, exist in the literature, however, more sophisticated approaches are required in order to ensure that BCO performance compares (or even outperforms) other bio-inspired MH methods. We believe that ML techniques for BCO parameter calibration will 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. Although it has been demonstrated that BCO satisfies requirements of the model-based convergence, 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 in such a way that the BCO convergence rate increases.

Within the second part, objective is to implement the BCO method for artificial neural network (ANN) training. Calculating appropriate values for weighting coefficients of ANN can be formulated as an continuous optimization problem. The objective function is defined as the sum of differences 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 sum. 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 calculating weighting coefficients of ANN. 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. Today, as an institutional member of the European Mathematical Society, MISANU is the unique center for mathematically-oriented fundamental and technological research in Serbia, employing more than 70 full-time researchers. 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 doing 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, mechanics, geometry, operator theory, and analysis are the most influential ones. The main activities in MISANU involve participation in national and international scientific projects, conferences, workshops and seminars as well as informal research groups. At the moment, MISANU employs more than 45 PhDs and 25 PhD students. Still, the Institute relies very heavily and successfully on its numerous associate members who always have played essential roles in managing the activities in MISANU. They are scholars from all over Serbia, which is an opportunity for MISANU to keep close contacts with all our universities, and particularly with faculties of science and mathematics and schools of engineering. Aiming to be the service center for all Serbian mathematicians, MISANU has the largest library with more than 15000 books and hundreds of scientific journals in mathematics, computer science, physics and other relevant fields. The library also provides the access to various data bases with scientific content. 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.

Accommodation in Belgrade is not 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.