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IN MEMORIAM
NENAD MLADENOVIĆ (1951-2022)

Nenad Mladenović was born on April 28, 1951 in Jagodina. He finished primary and secondary school in Belgrade. He graduated from the Department of Mathematics (major Cybernetics) at the Faculty of Natural Sciences and Mathematics, University of Belgrade in 1976. He received his master degree in 1982 from the Faculty of Organizational Sciences, University of Belgrade with a master's thesis titled "Comparative analysis of some nonlinear programming methods". He defended his doctoral thesis "New nonlinear programming methods with application in location, allocation and transportation problems" in 1988 at the Faculty of Organizational Sciences. On both theses, his mentor was Professor Jovan Petrić.

Nenad Mladenović got his first job in 1976 as a professor of mathematics at the 10th Belgrade Gymnasium, and after completing his military service, at the 9th Belgrade Gymnasium (which at that time had the same curriculum as the Mathematical Gymnasium), where he remained until 1985. After defending his master thesis, Mladenović joined the scientific research project *Planning and Programming of Nutrition in the JNA*, led by Professor Jovan Petrić, and in 1985 he got the position of teaching assistant for *Decision Theory and Econometric Methods* at the Faculty of Organizational Sciences. Dr Mladenović was promoted to the position of assistant professor for *Methods of Optimization* in 1988. Due to his demonstrated abilities in conducting, coordinating and managing scientific research projects, in 1989 Dr Mladenović was elected as a vice dean for scientific research. In 1991, at the invitation of Professor Pierre Hansen, winner of the

European Gold Medal for Operations Research and a member of the Canadian Academy of Sciences, Dr Mladenović went to the University of Montreal for scientific training, but instead of the planned one year paid leave, he stayed there till 1997. In Montreal, he worked as a researcher at one of the world's largest centre for operational research - the GERAD Institute, where he actively participated in helping students to prepare their master and doctoral theses, and gave lectures on Operations Research at McGill University. He was also involved in three industrial projects with leading Canadian companies (Hydro Quebec, Ultramar Oil), which aimed to develop software to optimize some production processes. In 1997, Dr Mladenović returned to Belgrade, but, since he could not find a suitable job there, in 1998 he went to Montreal again to the GERAD Institute. For the 1998/99 school year, he applied for and received the position of visiting professor at the Free University (SMG) in Brussels, an honorary position awarded to leading professors in his field. In addition to his own research, he was working in Brussels on the development of software for optimal routing of oil tankers.

Dr Mladenović got a job at the Mathematical Institute of Serbian Academy of Sciences and Arts (SASA) in 2000 as a senior research associate, and in 2002 he was elected a scientific advisor. At the Mathematical Institute, he managed scientific research projects *Mathematical Models and Methods of Optimization* and *Mathematical Models and Methods of Optimization of Large Systems* financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia. Dr Mladenović also led two research projects in the UK: *Variable Neighborhood Search in Clustering and Data Mining* and *p-Center Problem with Formulation Space Search*, the *Global Supply Chain and Constrained Vehicle Routing* project in France and the *Heuristic optimization* project in Russia. At the same time, Dr Mladenović participated in numerous other scientific research projects in Canada, Spain, France, Russia, Kazakhstan, Brazil and China.

From 2006-2016 Dr Mladenović, engaged with a third of his working time worked at the Faculty of Organizational Sciences as a professor of *Location Theory*, teaching undergraduate and doctoral students subjects *Nonlinear Programming*, *Combinatorial Optimization* and *Metaheuristics*. He wrote a textbook for the subject *Location Theory*. Dr Mladenović remained at the Mathematical Institute until his retirement in 2018. From 2018-2022, he was hired at Khalifa University of Science and Technology in Abu Dhabi.

Dr Mladenović, as a visiting professor, visited several well-known world universities. From 2005-2013 he taught *Operations Research*, *Heuristic Optimization* and *Operations Management* at the Faculty of Mathematics, University of Birmingham and Brunel University in London. From 2013-2016, as an international chair, he gave lectures on *Mathematical Optimization Methods* to doctoral students at the University of Valenciennes in France. In Seville, in 2009, he was honoured, together with selected professors from around the world, to take a course for promising doctoral students within the European program *Advanced School on Mathematical Modelling at IMUS*. From 2014-2017, as the winner of an international competition in Brazil, he taught several courses to doctoral students at three Brazilian universities: Federal University of Rio Grande del Norte, Natal, University of Joao Pessoa, Paraiba and University of Ouro Preto, Minas Gerais. As a mega-grant leader of the project announced by the Ministry of Kazakhstan, he taught master students of mathematics several subjects in optimization and mathematical programming at two universities in Alma-Ata: Al Farah University of Kazakhstan and Kazakhstan Technical University. In 2010, at the Royal Juan Carlos University in Madrid, he held a seven-day course in *Variable Neighborhood Search* for master and doctoral students. At

the end of 2016, he held an intensive seven-day course for doctoral students at the most prestigious mathematical faculty in Spain, the Universidad Complutense de Madrid, Faculdad de Ciencias Mathematicas. In 2017, he held a one-month course *Heuristic optimization in Big data* for master and doctoral students at the University of Lille in France. Dr Mladenović had many years of cooperation with the Department of Management of the Hong Kong Polytechnic University in Hong Kong, the School of Business Administration of the University of Prince Edwards Island in Canada, and the University of La Laguna in Tenerife, Spain. He also lectured at universities in Novosibirsk, Samara, Vladivostok, Kaiserslautern, Darmstadt, Madrid, Beijing, and Kuwait. At the universities in Belgrade, Novi Sad, Tenerife, London, Birmingham and Alma-Ata, Dr Nenad Mladenović supervised the preparation of several doctoral and master dissertations in the field of operations research.

Dr Mladenović has been a member of the Scientific Society of Serbia since 2004, and in 2012 he was elected as a member of the European Academy of Sciences *Academia Europea*, with its headquarter in London. He has been a member of the Academy of Nonlinear Sciences since 2010. In 1999, together with Professor Hansen, he received the award by the Yugoslav Association for Industrial and Applied Mathematics for the best scientific work published in the past year, and in 2001 he took over the presidency of this association. He is the winner of the Charter for Merits in the Development of Operational Research in Serbia. He was a visiting member of the GERAD Institute in Montreal. He gave invited and introductory lectures at more than 40 international conferences and has chaired the European Working Group on Location Theory.

Dr Mladenović was a member of the program committee of numerous scientific conferences. He was a permanent member of the program committee of the *Symposium on Operations Research SIM-OP-IS* (since 1990), and the *Balkan Conference on Operations Research* (since 2007). As one of the two authors of the world-renowned metaheuristics Variable Neighborhood Search (VNS), Dr Mladenović was appointed chairman of the program committee of two scientific conferences called *Mini EURO Conference on VNS*, held in Spain in 2005 and in Montenegro in 2012. Following a growing interest of the scientific community, international conferences dedicated to his method Variable Neighborhood Search were organized at the regular basis, where Mladenović participated in the organization of conferences in Tunisia (*3rd International Conference on VNS*, 2014), Spain (*4th International Conference on VNS*, 2016), Brazil (*5th International Conference on VNS*, 2017), Greece (*6th International Conference on VNS*, 2018), Morocco (*7th International Conference on VNS*, 2019), United Arab Emirates (*8th International Conference on VNS*, 2021). In addition to the above, Mladenović was a member of the program committee of the *International Network Optimization Conference* (*INOC 2013*), *Metaheuristics International Conference* (*MIC 2013*), *Global Optimization Workshop* (2012), *SIAM International Conference on Data Mining* (*SDM 2008), Learning and Intelligent Optimization LION II, III, IV*) (2007-), *Matheuristics Workshop* (2007-).

Dr Mladenović was a member of the Advisory board for the journals published by the well-known publisher Elsevier and a regular reviewer for the American Mathematical Society. He was a member of the editorial board of *Yugoslav Journal of Operations Research* (YUJOR) since its founding in 1990, and since 2010, one of the three editors-in-chief, where in 2022, he took over the position of the sole editor-in-chief. In addition to editing *YUJOR*, Dr Mladenović was a member of the editorial board of 14 other scientific journals, of which we single out: *TOP* (Associate Editor, 2012-), *EURO Journal on*

Computational Optimization (2012-), *Journal on Optimization* (2009-), *International Journal of Metaheuristics* (2008-), *International Journal of Mathematics in Operational Research* (2008-), *Computers and Operations Research* (2005-) and *Computer Science and Information Systems* (*COMSIS*, 2003-). He was a guest editor of special issues of the *European Journal of Operational Research*, *IMA Journal of Management Mathematics*, *Journal of Applied Mathematics*, *Journal of Global Optimization* and *Computers and Operations Research*. He reviewed papers for almost all leading journals in operations research.

Dr Nenad Mladenović was a very productive researcher, who gained an enviable world reputation in the field of operations research, dealing with problems of decision-making and management in complex systems. He published about 200 papers in scientific journals, 70 papers in edited conference proceedings and 40 books and chapters in scientific monographs. His results have had a great impact in the world. According to Google Scholar, they have been cited 25,422 times till today, and his h-index is 59. One of the most significant scientific results he has achieved is the development of original approximate methodology for solving combinatorial and global optimization problems, called Variable Neighborhood Search. Dr Mladenović proposed this methodology in 1995, and since then, it has gained the status of one of the leading general heuristic methods. It is known that the problems of combinatorial and global optimization are easy to formulate but difficult to solve with exact methods. Therefore, they are usually solved by using approximate or heuristic methods adapted to the specifics of individual optimization problems. With the generalization of special heuristics, various general heuristic methods were formed, the so-called metaheuristics. Working on the practical problem of designing an oil pipeline in South Gabon during his visit to Montreal, Dr Mladenović came up with the idea to use the fact that the local minimum with respect to one neighborhood structure (induced from a certain metric) is not necessarily a local minimum with respect to another type of neighborhood. In addition, the global minimum, which is almost impossible to find in real time on the fastest modern computers, is local with respect to all types of neighborhoods. Following these simple facts, Mladenović first independently, and then together with Professor Hansen, elaborated several variants of the VNS and showed their applicability to various optimization problems.

Dr Mladenović gave lectures on the Variable Neighborhood Search at several international conferences, including: *II* and *III International Congress on Metaheuristics*, held in Nice in 1997 (*MIC'97*), and in Rio de Janeiro in 1999 (*MIC'99*). After that, this method became one of the most popular metaheuristics. The importance of this method is best illustrated by the following data:

(i) article: Mladenović N., Hansen P., Variable neighborhood search, *Computers and Operations Research* 24, 1097-1100, 1997, cited 4887 times (source Google Scholar);
(ii) invited review article: P. Hansen, N. Mladenović, Variable neighborhood search: Principles and Applications, *European Journal of Operational Research* 139 (4), 2001, 449-467, is included in the collection of 30 most influential articles published in *European Journal of Operational Research* since its founding in 1977;
(iii) in the period 2005-2021, 8 scientific conferences dedicated to the Variable Neighborhood Search were organized.

Most of the papers published by Dr Nenad Mladenović and co-authors after 2000 relate to different methodological variants of the VNS and the application of the VNS to various optimization problems, such as the traveling salesman problem, the multisource Weber

problem, the object clustering problem by the criterion of the minimum sum of the squares of the distances, the location problem, the problem of finding the global optimum of a continuous function, etc. Mladenović initiated and developed two more general heuristic methods, which confirms his originality and inventiveness over a longer period of time: Formulation Space Search (FSS), 2005 and Less is More Approach (LIMA), 2016. A special group of Mladenović's works consists of theoretical contributions. which refer to the conditions for the existence of a degenerate solution of some continuous location problems and finding a formula for the dual gap of a simple location problem. Together with the co-authors, he proposed a new method for solving large asymmetric problems of vehicle routing and proved that the method is exact, i.e., finds optimal solutions. Another important characteristic of Dr Mladenović's work is the great applicability of his scientific results to real problems of large dimensions, such as problems in the oil industry, urban planning, traffic, telecommunications, searching large data sets, etc.

The bibliography of Dr Nenad Mladenović can be found at the site of the Mathematical Institute of SASA: http://www.mi.sanu.ac.rs/novi_sajt/biography/NenadMladenovic.pdf From the bibliography it can be seen that in less than 6 years, from 2017-2022, he has published 60 articles in scientific journals, which is almost a third of all articles he has published. This is the best illustration of the fact that death interrupted him in full creative momentum. But the Variable Neighborhood Search and its numerous applications, death cannot and will not erase.

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