Short CV of the advisor

Assoc. Prof. Nysret Musliu
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PROFESSIONAL EMPLOYMENT:

Since 04/1999: TU Wien, Institute of Logic and Computation:

Current position: Associate Professor and the Head of the Christian Doppler Laboratory for Artificial Intelligence and Optimization for Planning and Scheduling

Previous positions: Priv. Doz., Univ.Ass/Ass. Prof., PostDoc Researcher, Research Assistant

EDUCATION:

October 2007: Habilitation, Faculty of Informatics, TU Wien

1998 - 2001: Ph.D. studies at the TU Wien

1990 - 1996: Dipl.-Ing degree, University of Prishtina, Kosova

HONORS & AWARDS:

2022: Winner (together with Lucas Kletzander) of the Best Industry and Applications Track Paper Award, ICAPS 2022

2019: Winner (together with Reinhard Pichler) of Informatics Europe 2019 Best Practices in Education Award

2017: Christian Doppler Laboratory for AI and Optimization for Planning and Scheduling

2016/17: Third place (together with Michael Abseher and Stefan Woltran) in the PACE Challenge (2016 and 2017)

1995: Distinguished student ("Student i dalluar") award from the University of Prishtina, Kosova

CURRENT RESEARCH TOPICS:

- Problem Solving and Search in AI, Metaheuristics, Constraint Solving, Planning and Scheduling, Machine Learning and Optimization

RESEARCH GRANTS (Selection):

- (2017-2024) Christian Doppler Laboratory for Artificial Intelligence and Optimization for Planning and Scheduling
- (2022-2025) Reverse supply chain of residual wood biomass
- (2022-2025) AI-driven collaborative supply and demand matching platform for food waste reduction in the perishable food supply chain
- (2012-2017) ARTE: Artificial Intelligence in Employee Scheduling

ORGANIZATION AND CHAIRING OF CONFERENCES:

Conference Chair of the CPAIOR 2021 and CPAIOR 2020, PC Co-Chair CPAIOR 2020, PC Co-Chair and Local Organization Chair of PATAT 2018.

PUBLICATION SUMMARY:

More than 100 scientific articles in peer-reviewed journals and conferences including Journal of Artificial Intelligence Research, ACM Transactions on Intelligent Systems and Technology, IEEE Intelligent Systems, Journal of Scheduling, Computers and OR, Annals of OR, European Journal of OR, IJCAI, AAAI, EvoCOP, GECCO, ICAPS, KR, CP, CPAIOR, PATAT. 1975 citations, h-index 23 (scholar.google.com, May 15th, 2023).

Description of the research group

At the TU Wien the project will be carried out in the the Institute of Logic and Computation, Research unit of Databases and Artificial Intelligence (DBAI).

The TU Wien is Austria's largest research and educational institution in the field of technology and natural sciences. More than 4,000 scientists are researching "technology for people" in five main research areas at eight faculties. The content of the studies offered is derived from the excellent research. More than 27,000 students in 55 degree programmes benefit from this. As a driver of innovation, TU Wien strengthens the business location, facilitates cooperation and contributes to the prosperity of society.

The DBAI research unit has been undertaking research on artificial intelligence and databases since 1984. It has been working intensely for many years on topics realted to this project such as planning and scheduling, AI problem solving techniques, metaheuristics, constraint solving, algorithm selection, instance space analysis, and machine learning. The group has successfully carried out several research projects on artificial intelligence and optimization including the Christian Doppler Laboratory for Artificial Intelligence and Optimization for Planning and Scheduling. The advisor (Nysret Musliu) is the head of this CD Labortory that includes currently four postdoc researchers, and three master students.

Other relevant information

The DBAI research unit is located in Favoritenstraße 9, A-1040 Wien, Austria. Office space will be provided by the group. The powerful servers of DBAI will be available for the longer and intensive algorithm experiments that are planned.

If the project cannot be completed within three months, funding for two additional months will be considered by the CD Laboratory.

Description of the work to be carried out by the student: Automated Algorithm Selection and Instance Space Analysis for Scheduling Problems

Scheduling problems arise in various industries and organizations, such as business, engineering, healthcare, and education. Typical problems include project planning and scheduling, machine scheduling, timetabling in sports and transportation, planning and scheduling in healthcare, and workforce scheduling.

Considering that the majority of the scheduling problems mentioned earlier are NP-hard, as indicated by the No-free Lunch theorem [7], it is unrealistic to expect that all solving methods will perform equally well on every instance. Therefore, it becomes essential to choose the appropriate algorithm for a specific instance based on the analysis of instance space.

The *algorithm selection problem* consists in determining the most suitable algorithm among the available options to solve a given problem instance. Rice [3] proposed a model that includes four key elements: problem space, algorithm space, performance measure, and feature space. Given these components, the objective is to determine a selection mapping (S) that enables the (offline) identification of the optimal algorithm ($a = S(f(x))$) for a particular problem instance (x) based on its features ($f(x)$) and evaluated through a performance measure. To derive the selection mapping S, supervised machine learning techniques can be employed. The effectiveness of these methods in making accurate predictions is greatly influenced by the quality and quantity of the training data at hand. Consequently, it becomes vital to supply appropriate problem instances and relevant features. The objective is to assess the merits and limitations of proposed algorithms through a comprehensive analysis of their strengths and weaknesses. In this regard, the instance space analysis methodology [4] has been applied to various problems including combinatorial and continuous optimization as well as machine learning.

In this project, the candidate will focus on one of the recently introduced scheduling problems in the literature. The options include production leveling problem [5], oven scheduling problem [1], and parallel machine scheduling [2, 6] with new objectives. The chosen problem will be solved with a set of different techniques, embracing the state of the art. Possible options include but are not limited to, local search metaheuristics, evolutionary algorithms, and hybrid techniques. One of the key research objectives is to identify specific features of problem instances for the chosen application domain, as this is essential for automating algorithm selection and instance space analysis. Consequently, the candidate will examine the instance space using the devised features and develop methods for generating a diverse range of instances. Afterward, they will conduct a thorough analysis of the general behavior of the solution methods.

References

[1] Marie-Louise Lackner, Christoph Mrkvicka, Nysret Musliu, Daniel Walkiewicz, and Felix Winter. Exact methods and lower bounds for the oven scheduling problem. *Constraints Journal, 2023. arXiv preprint arXiv:2203.12517*, 2022.

[2] Maximilian Moser, Nysret Musliu, Andrea Schaerf, and Felix Winter. Exact and metaheuristic approaches for unrelated parallel machine scheduling. *Journal of Scheduling*, 25(5):507–534, 2022.

[3] John R. Rice. The algorithm selection problem. volume 15 of *Advances in Computers*, pages 65–118. Elsevier, 1976.

[4] Kate Smith-Miles and Mario Andrés Muñoz. Instance space analysis for algorithm testing: Methodology and software tools. *ACM Comput. Surv.*, 55(12), mar 2023.

[5] Johannes Vass, Marie-Louise Lackner, Christoph Mrkvicka, Nysret Musliu, and Felix Winter. Exact and meta-heuristic approaches for the production leveling problem. *Journal of Scheduling*, 25(3):339–370, 2022.

[6] Felix Winter, Sebastian Meiswinkel, Nysret Musliu, and Daniel Walkiewicz. Modeling and solving parallel machine scheduling with contamination constraints in the agricultural industry. In *28th International Conference on Principles and Practice of Constraint Programming*, 2022.

[7] David H. Wolpert and William G. Macready. No free lunch theorems for optimization. *IEEE Trans. on Evo. Comp.*, 1(1): 67–82, 1997.