

SPECIES SCHOLARSHIP



1. ACADEMIC HOST: PROF. DR. DIRK SUDHOLT



Chair of Algorithms for Intelligent Systems

University of Passau
Innstr. 43
94032 Passau
Germany ✉

Research Interests

Randomised algorithms and algorithmic analysis
Evolutionary algorithms
Swarm intelligence and estimation of distribution algorithms

Work Experience

since 2020 Full Professor, University of Passau, Passau, Germany
2017–2020 Senior Lecturer in Computer Science, University of Sheffield, Sheffield, UK
2012–2016 Lecturer in Computer Science, University of Sheffield, Sheffield, UK
2010–2011 Research fellow in the group of Prof. Xin Yao
University of Birmingham, Birmingham, UK
2009–2010 Research scholar in the group of Prof. Richard M. Karp
International Computer Science Institute, Berkeley, USA
2005–2009 Research assistant, Technische Universität Dortmund, Dortmund, Germany

Education

2005–2008 Dr. rer. nat., Technische Universität Dortmund, with distinction
Title: Computational complexity of EAs, hybridizations, and swarm intelligence
Advisor: Prof. Dr. Ingo Wegener
1999–2004 Diplom-Informatiker, Universität Dortmund, with distinction

Awards and Achievements

2007–2021 Best paper awards at GECCO 2007, 2008, 2010, 2011, 2012, 2014 (x2), 2021
2010 Best paper award at PPSN 2010
2009–2010 Postdoctoral scholarship from the German Academic Exchange Service (DAAD)

Publications

130+ peer-reviewed publications
3600+ citations and h -index of 35 (Google Scholar on 09/05/2023)

2. THE CHAIR OF ALGORITHMS FOR INTELLIGENT SYSTEMS

Our research: The chair covers the algorithmic analysis of general-purpose optimisation paradigms that draw inspiration from biological systems. Perhaps the most popular example of such paradigms is Evolutionary Algorithms which mimic Darwinian principles such as survival of the fittest to artificially evolve candidate solutions for optimisation and design problems. Other practically successful paradigms include Swarm Intelligence such as Ant Colony Optimisation or Particle Swarm Optimisation, these are based on the collective behaviours, which are often recognised as intelligent, of animal swarms. We are also interested in the probabilistic model-building algorithms, also referred as Estimation of Distribution Algorithms, which update and enhance models to sample good solutions, instead of evolving the solutions.

We work on providing a theoretical foundation for understanding the working principles behinds these heuristic algorithms through quantifying how quickly they find satisfactory solutions for various problems. This exposes how the performance depends on algorithmic parameters, problem structures and design choices. We firmly believe that such foundation is necessary in assisting the design of better bio-inspired optimisation algorithms and even to invent new and better algorithms, for optimisation problems in practices.

Our expertise: The chair currently comprises of one professor (Dirk Sudholt), two Postdocs (Duc-Cuong Dang and Andre Opris), and one PhD student (Marcus Schmidbauer) who has just started this year. We have teaching and research experiences in Theoretical Computer Science, mainly in the algorithmic analysis of traditional algorithms, Randomised Algorithms, and Randomised Search Heuristics, and in Complexity Analysis of Combinatorial Optimisation Problems; but also in Pure Mathematics (Andre Opris), in Stochastic Processes (Marcus Schmidbauer). Duc-Cuong Dang also has experience in various practical optimisation problems with applications in Management Science, specifically in the fields of Transportation, Utilities and Environmental Services, Humanitarian Logistics and Disaster Management, Healthcare and Organ-Transplantation Management.

We have been collaborating with colleagues from different countries and on different continents, for example Adelaide (Australia), Birmingham (UK), Duluth (USA), Paris (France), Shenzhen (China), Zürich (Switzerland), etc. We publish our research work regularly at the top conferences in Evolutionary Computation and in Artificial Intelligence, such as GECCO, FOGA, PPSN, AAAI, EvoStar, and in the first tier journals of these fields including Artificial Intelligence, IEEE Transactions on Evolutionary Computation, ACM Transactions on Evolutionary Learning and Optimisation, and Evolutionary Computation.

3. PROJECT DESCRIPTION

We are looking for enthusiastic students with excellent analytical skills. Having good programming skills is a plus but the student should also not be afraid of mathematical analyses with rigorous proofs. If you have enjoyed courses on Algorithms and Complexity, this is a good sign that you may fit our search profile.

We offer two types of topics that you can work on and collaborate with us. The first is aligned with the current research of our group; and the other one can be based on your PhD research project. We expect the findings to be presented in forms of rigorous mathematical proofs which display firm knowledge about the studied algorithms/problems. Experiments can be conducted to complement the findings.

Uncertainty meets multi-objectives: Recently our group has conducted rigorous runtime analyses of the famous NSGA-II in some complex settings [1, 2]. Particularly, in [2] while we can show that the algorithm outperforms the simpler algorithm called GSEMO under a specific noise model, several open questions have spawned. For example, a next step is to ask how the algorithm performs on under a slightly more complex noise model, or under the Gaussian noise? We noticed that NSGA-II is inefficient even in our noise model when the frequency of the noise near $1/2$, so another possible next step is to ask what remedies or modifications are required for the algorithm to adapt in such regimes? There are also other open questions related to the two papers which we find that is more appropriate to discuss in-person, but overall to answer them new analyses need to be conducted and new results are waiting to be discovered.

Analysis of your algorithm and/or on your problem: As PhD students, you may have set up your own PhD project and research directions. Maybe you have already worked on implementing a paradigm with your own tweaks and variants to solve some specific combinatorial problem and you have already obtained promising experimental results. Now, you want to have a deeper understanding of the tweaks and variants, like why they perform so well on some specific instances and to make rigorous statements out of these findings. We can collaborate to work towards such results. We have experience working with practical algorithms like the NSGA-II [2] and the P3 algorithm [3].

Our work plan is the following. During the first two weeks of the visit, we will get to know your story and background, and discuss the above topics to find the one that fits you the most and that is feasible within the 3-month stay. The rest of the visit is fully dedicated to work on the chosen topic and tracking the progress (aka paper writing).

Related publications

- [1] D.-C. Dang, A. Opris, B. Salehi, and D. Sudholt. A proof that using crossover can guarantee exponential speed-ups in evolutionary multi-objective optimisation. In *Proceedings of the AAAI Conference on Artificial Intelligence, AAAI 2023*, pages to appear, preprint available at <http://arxiv.org/abs/2301.13687>. AAAI Press, 2023.
- [2] D.-C. Dang, A. Opris, B. Salehi, and D. Sudholt. Analyzing the robustness of NSGA-II under noise. In *Proceedings of the Genetic and Evolutionary Computation Conference GECCO '23*, page to appear. ACM Press, 2023.
- [3] B. W. Goldman and D. Sudholt. Runtime analysis for the parameter-less population pyramid. In *Proceedings of the Genetic and Evolutionary Computation Conference GECCO '16*, pages 669–676. ACM Press, 2016.

4. OTHER RELEVANT INFORMATION

City of Passau

Situated on the Germany-Austria border, and on the joint between the Danube, the second-largest river in Europe, the Inn that crosses Switzerland-Austria-Germany, and the Ilz, which runs through the Bavarian Forest, Passau is known as the City on the Three Rivers (Dreiflüssestadt in German). Its inhabitants and visitors can enjoy water-way access to various places in Europe and many leisure activities. During summer there are cruise ships to Linz or Vienna, and you can explore the sights of cities, forests and life in Lower Bavaria and West Austria. The city also hosts two of the biggest funfairs in Eastern Bavaria, called Passauer Maidult (between April and May) and Passauer Herbstdult (during autumn). These attract tens of thousands of visitors with beer tents, funfair booths, live music, funfair rides and a costume parade (always on the first Sunday of Maidult).



The historical sights of the city includes the famous St Stephan Cathedral which houses the biggest cathedral organ in the world with 17 974 pipes and 233 registers; the Pilgrimage Church “Mariahilf” with its 321 steps adorned with many votive tablets and leading up to the pilgrimage chapel; the Fortress Veste Oberhaus which is one of the largest Middle Age surviving castle complexes in Europe, providing the unique panoramic view to the city and the rivers; and various churches and monasteries surrounding the city.

University of Passau

Established on January, 1st 1973, the University of Passau is currently the youngest university in Bavaria. The university buildings are located along the Inn street on one side and on the bank of the Inn river on the other side. The campus offers students, academics and visitors an idyllic walkway on the side of river and a scenic view to nature life on the river and partially to Austria on the other side.

The University of Passau is renowned for its modern facilities and its international reputation. In 2019, The Times Higher Education ranking of Young Universities (50 years of existence or less) put our university in the 16th place worldwide and the 2nd place in Germany. 15.18 % of our students are international, and come from 41 countries all around the world (data of the winter semester 2021/2022). Our Faculty for Computer Science and Mathematics offers various degrees in Computer Science, Pure and Applied Mathematics at Undergraduate, Master and Doctoral levels. We also provide training and qualifications for teachers in high schools and grammar schools in the State of Bavaria. Our offices are located at the IT-Zentrum and International House (ITZ/IH building) which has a picturesque view to the river.

The city of Passau and the nearby areas provide many possibilities for accommodation. Online platforms exist for directly getting in touch with the property owners. The Welcome Centre at the University of Passau can assist you during the process of finding an accommodation, especially with communications in German. The centre also has competent staff to help you out with administrative procedures in Germany.