M2 Research Internship Offer for M2 Students at ENSL: Design and Analysis of Randomized Search Heuristics

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Host institution: Laboratoire d'informatique de l'École polytechnique (LIX), Palaiseau, Île de France, France.

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Keywords: Heuristic search, genetic algorithms, artificial intelligence, theory.

Context: Runtime analysis of randomized search heuristics. Randomized search heuristics such as local search variants, genetic algorithms, estimation-of-distribution algorithms or ant colony optimizers are successfully used in many application areas. In contrast, their theoretical understanding, which could guide the design of such algorithms, is much less developed. Nevertheless, for a good twenty years now there have been increased attempts to shed some light on the working principles of randomized search heuristics, mostly with the methods that have been used successfully in classic algorithms for more than hundred years. The fruits of these efforts have become visible in the last years. Not only do we understand much better how these algorithms work, we also have some rigorous advice how to choose their parameters, and even some new algorithms have been developed based on theoretical insights.

Topic of this internship: In this young and fast-changing area, it is difficult to decide on a topic too far ahead. At the same time, there is much work to be done in different subareas. For this reason, the particular topic of the internship will be discussed between the supervisor and the student, taking into account the student's background and interests as well as what are currently the most interesting research questions. Areas in which the supervisors have successfully worked (and supervised students) include optimal static and dynamic parameter settings, ant-colony optimizers, estimation-of-distribution algorithms, and evolutionary multi-objective optimization. Examples of papers stemming from students' projects in these areas include [WZD21, BBD21, ZLD22, DQ23, CDH+23, BDK23], which all can be found on the arXiv preprint server.

Regardless of the precise topic, the task in this research internship will be to explore a specific topic in the theory of randomized search heuristics, to conduct interesting, novel, and high-quality scientific work on a particular research question, and to write down the results in the form of a scientific paper that can be submitted to a leading conference. All this will happen in close collaboration with the supervisors.

Prerequisites: As should be clear from the description above, this is a topic with a strong connection to current research. As such, the intern should have an interest in doing actual research, and consequently, a pronounced scientific curiosity. A solid background in computer science, mathematics, or applied mathematics is necessary. Having attended theory of algorithms courses with joy and very good marks is a clear indication that this is a suitable topic for your internship.

Funding: We do not have funding particularly dedicated to this internship, but we are very optimistic that we will find funding, from our projects or from our lab, to support the intern should he/she have no support from ENSL. In the past, we never had to turn down a candidate for an internship for reasons of funding.

Future PhD: The research conducted in this internship is perfectly suitable to be continued in a PhD project, and the supervisors would love to do so (assuming the internship goes well). Again, we have no money earmarked for this, but Polytechnique has a decent number of PhD stipends, so it should not be a problem to secure such funding for an excellent student. In the past, all our M2 interns who wanted to do a PhD with us received an offer for such a stipend.

References

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[CDH+23] Sacha Cerf, Benjamin Doerr, Benjamin Hebras, Jakob Kahane, and Simon Wietheger. The first proven performance guarantees for the Non-Dominated Sorting Genetic Algorithm II (NSGA-II) on a combinatorial optimization problem. In *International Joint Conference on Artificial Intelligence, IJCAI 2023*, pages 5522–5530. ijcai.org, 2023.

[DQ23] Benjamin Doerr and Zhongdi Qu. From understanding the population dynamics of the NSGA-II to the first proven lower bounds. In *Conference on Artificial Intelligence, AAAI 2023*, pages 12408–12416. AAAI Press, 2023.

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