



## **School of Computing, Engineering, and the Built Environment Edinburgh Napier University**

### **PHD STUDENT PROJECT**

#### **Application instructions:**

Detailed instructions are available at :

<https://www.napier.ac.uk/research-and-innovation/doctoral-college/how-to-apply>

*Prospective candidates are encouraged to contact the Director of Studies (see details below) to discuss the project and their suitability for it.*

### **Project details**

#### **Supervisory Team:**

- DIRECTOR OF STUDY: Dr Kevin Sim (Email: [k.sim@napier.ac.uk](mailto:k.sim@napier.ac.uk))
- 2<sup>ND</sup> SUPERVISOR:

**Subject Group:** Computer Science

**Research Areas:** Artificial Intelligence

**Project Title:** Machine Learning and Hyper-heuristics

#### **Project description:**

Hyper-heuristics (HH) have been successfully used to solve combinatorial problems from different problem domains, such as vehicle routing, bin packing and constraint satisfaction problems. HH were introduced under the acclaim that they are applicable to different problems without modification, in an attempt to produce more generalizable techniques that could be applied without the time consuming task of tailoring and tuning an algorithm specifically for the problem. Results on different problem domains indicate that HH suffer from the same issues as other biologically inspired search methods, namely that increasing performance on one problem domain, or a subset of problem instances from a domain has a negative effect on the performance on other problem domains, or different problem instances.

The task of tuning an algorithm is a complex task that often requires expert input, and a large amount of time and resources. Once tuned this information is typically disregarded and the algorithm needs retuned when faced with a different problem. The project will use machine learning to identify correlations between algorithm

performance and problem attributes in an attempt to identify the best approach to be used for solving a particular problem. A background in biologically inspired search algorithms is essential as is a good knowledge of machine learning techniques and combinatorial search problems.

### References:

- [1] Hart, E., Sim, K.: A hyper-heuristic ensemble method for static job-shop scheduling. *Evolutionary Computation* 24(4), 609{635 (2016)
- [2] Hart, E., Sim, K., Gardiner, B., Kamimura, K.: A hybrid method for feature construction and selection to improve wind-damage prediction in the forestry sector. In: GECCO. pp. 1121-1128. ACM (2017)
- [3] Sim, K., Hart, E., Paechter, B.: A lifelong learning hyper-heuristic method for bin packing. *Evolutionary Computation* 23(1), 37{67 (2015)
- [4] Alissa, M., Sim, K., & Hart, E. (2019). Algorithm selection using deep learning without feature extraction. In A. Auger & T. St tzle (Eds.), *Proceedings of the Genetic and Evolutionary Computation Conference, GECCO 2019, Prague, Czech Republic, July 13-17, 2019* (pp. 198 206). ACM. <https://doi.org/10.1145/3321707.3321845>
- [5] Alissa, M., Sim, K., & Hart, E. (2020). A deep learning approach to predicting solutions in streaming optimisation domains. In C. A. C. Coello (Ed.), *GECCO 20: Genetic and Evolutionary Computation Conference, Canc n Mexico, July 8-12, 2020* (pp. 157 165). ACM. <https://doi.org/10.1145/3377930.3390224>
- [6] Alissa, M., Sim, K., & Hart, E. (2021). A Neural Approach to Generation of Constructive Heuristics. *IEEE Congress on Evolutionary Computation, CEC 2021, Krak w, Poland, June 28 - July 1, 2021*, 1147 1154. <https://doi.org/10.1109/CEC45853.2021.9504989>
- [7] Alissa, M., Sim, K., & Hart, E. (2022). Automated Algorithm Selection: from Feature-Based to Feature-Free Approaches. *CoRR*, abs/2203.13392. <https://doi.org/10.48550/arXiv.2203.13392>
- [8] Hart, E., & Sim, K. (2018). On Constructing Ensembles for Combinatorial Optimisation. *Evol. Comput.*, 26(1). [https://doi.org/10.1162/evco\\_a\\_00203](https://doi.org/10.1162/evco_a_00203)
- [9] Sim, K., & Hart, E. (2022). Evolutionary Approaches to Improving the Layouts of Instance-Spaces. In G. Rudolph, A. v Kononova, H. E. Aguirre, P. Kerschke, G. Ochoa, & T. Tusar (Eds.), *Parallel Problem Solving from Nature - PPSN XVII - 17th International Conference, PPSN 2022, Dortmund, Germany, September 10-14, 2022, Proceedings, Part I* (Vol. 13398, pp. 207 219). Springer. [https://doi.org/10.1007/978-3-031-14714-2\\_15](https://doi.org/10.1007/978-3-031-14714-2_15)

## Candidate characteristics

### Education:

A second class honour degree or equivalent qualification in Computer Science or a closely related discipline.problems.

### Subject knowledge:

- Biologically Inspired Optimisation algorithms
- Combinatorial Optimisation
- Good Programming Skills

### Essential attributes:

- Experience of fundamental computer science, with strong programming skills.
- Competent in statistical analysis and feature reduction techniques
- Knowledge of optimisation in combinatorial domains

- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

**Desirable attributes:**

- Knowledge of optimisation and/or problem solving techniques applied to real-world problems.