

# SPECIES Scholarship: Host Submission

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## 1 Short Bio

Gabriela Ochoa is a Professor of Computing Science at the University of Stirling in Scotland, UK. Her research lies in the foundations and methods of evolutionary algorithms and meta-heuristics, with an emphasis on fitness landscape analysis and visualisation, grey-box optimisation, autonomous search, and cross-disciplinary applications in healthcare. She holds a PhD from the University of Sussex, UK, and has worked at the University Simon Bolivar, Venezuela, and the University of Nottingham, UK, before joining Stirling. Her Google Scholar h-index is 47. She has been instrumental in creating and popularising the concepts of local optima networks (LONs) and search trajectory networks (STNs). She was the EiC for the Genetic and Evolutionary Computation Conference (GECCO) in two occasions: 2017 and 2025. She is an associate editor of the ACM Transactions on Evolutionary Learning and Optimisation (TELO), and member of the editorial board of the Evolutionary Computation Journal (ECJ). She is a member of the executive boards of both the SPECIES society, and ACM interest group in evolutionary computation (SIGEVO), where she edits the SIGEVolution newsletter. In 2020, she was recognised by the leading European event on bio-inspired algorithms, EvoStar, for her outstanding contributions to the field.

## 2 University of Stirling

The University of Stirling is a leading UK research-intensive university. In the most recent Research Excellence Framework (REF), the UK's system to assess research, 7% of our research has an outstanding or very considerable impact on society and more than 80% is world-leading or internationally excellent. About the city of Stirling: Also known as the "Gateway to the Highlands", Stirling is the perfect place to study. It combines the charm of a historic city with the buzz of a young community. And two of Scotland's main cities - Edinburgh and Glasgow - are around 40 minutes away, perfect for fun weekend adventures.

## 3 Funded Project and Research Group

The visiting PhD student will be interacting with members of an active research project and a research group described below.

Prof. Gabriela Ochoa leads a project funded by the Leverhulme Trust in the UK. The project, *Under-land: Understanding and Visualising Complex Optimisation Landscapes* aims to develop visualisation and analysis methods to aid in the comprehension of optimisation landscapes. The goal is to convey real-world optimisation scenarios, including multiple competing objectives of interest, complex problem representations, and uncertainty in a compact form, such as a network (graph). This will require different modelling and visualisation techniques. The project is a collaboration between the University of Stirling in Scotland and the University of Exeter in England. Each institution holds a professor and a senior research fellow working on the project.

The Data science And Intelligent Systems (DAIS) research group joins academics, researchers and PhD students within the Division of Computing Science and Mathematics at the University of Stirling. We are interested in the development, theory, and application of data-driven methods to understand, model and optimise the world.

### 3.1 Background and Definitions

**Local optima Local optima networks (LONs)** [3] are a graph-based model of fitness landscapes suited to characterising their global structure. LONs convey a compressed view of a landscape as a network (or graph) where nodes are local optima, according to a given neighbourhood, and edges are possible transitions among optima according to an escape operator.

**Search trajectory networks (STNs)** [2] are a graph-based tool to visualise and analyse the dynamics of any type of metaheuristic: evolutionary, swarm-based or single-point, on both continuous and discrete search spaces. STNs were originally proposed for single-objective optimisation and only recently extended to multi-objective optimisation. STNs have been applied to classical benchmark optimisation problems as well as to neuroevolution and genetic programming. There is still room for improving and applying this tool to new scenarios.

## 4 Proposed Projects

1. **Understanding Quantum Optimisation Formulations.** This project will look at applications of LONs to recently proposed real-world inspired benchmarks in binary representation[1]: Quadratic Unconstrained Binary Optimisation (QUBO). These problems are used to benchmark both classical and quantum optimisation algorithms. We will explore visualisation methods and assess the usefulness of the LON features in performance understanding and prediction.
2. **Understanding Multi-objective Problems.** So far, LONs and STNs have been applied to small multi-objective synthetic benchmark problems in combinatorial op-

timisation. This project will aim to construct and analyse LONs for larger problems in either continuous or discrete search spaces. We will consider existing benchmarks including real-world problems. We will explore visualisation methods and assess the usefulness of the LON and/or STN features in performance prediction.

3. **Understanding Complex Search Spaces and Algorithms.** This project will look at applications of LONs or STNs to neuroevolution, neural architecture search (NAS), genetic programming, or hyper-parameter search spaces, in order to improve our understanding of landscapes and effective algorithms in these complex domains. Apart from the genotypes, we will consider the phenotype, semantic and behavioural spaces as ways of representing more concise models.

## References

- [1] Thorsten Koch, David E. Bernal Neira, Ying Chen, Giorgio Cortiana, Daniel J. Egger, Raoul Heese, Narendra N. Hegade, Alejandro Gomez Cadavid, Rhea Huang, Toshinari Itoko, Thomas Kleinert, Pedro Maciel Xavier, Naeimeh Mohseni, Jhon A. Montanez-Barrera, Koji Nakano, Giacomo Nannicini, Corey O’Meara, Justin Pauckert, Manuel Proissl, Anurag Ramesh, Maximilian Schicker, Noriaki Shimada, Mitsuharu Takeori, Victor Valls, David Van Bulck, Stefan Woerner, and Christa Zoufal. Quantum Optimization Benchmarking Library - The Intractable Decathlon, August 2025. arXiv:2504.03832 [quant-ph].
- [2] Gabriela Ochoa, Katherine M. Malan, and Christian Blum. Search trajectory networks: A tool for analysing and visualising the behaviour of metaheuristics. *Applied Soft Computing*, 109:107492, 2021.
- [3] Gabriela Ochoa, Marco Tomassini, Sébastien Verel, and Christian Darabos. A study of nk landscapes’ basins and local optima networks. In *Genetic and Evolutionary Computation Conference (GECCO 2008)*, pages 555–562, Atlanta, GA, USA, 2008. ACM.