Time complexity Analysis of Bio-Inspired Computation

Introduction

Applications are invited for a fully-funded PhD studentship on the runtime analysis of bio-inspired computation techniques such as evolutionary algorithms, genetic algorithms, ant colony optimisation and artificial immune systems which are widely used heuristic search techniques at the heart of artificial intelligence.

Supervisor Bio

Professor Pietro S. Oliveto is Chair of the Algorithms research group. His main research interest is the rigorous performance analysis of bio-inspired computation techniques. He has successfully supervised PhD projects on the theoretical foundations of evolutionary computation, artificial immune systems, hyper-heuristics and automatic algorithm configurators.

About the project

Bio-inspired meta-heuristics, such as genetic algorithms, ant colony optimisation or artificial immune systems are general purpose algorithms that mimic powerful mechanisms from nature such as the natural evolution of species or the collective intelligence of animals with the goal of solving complex optimisation problems. They have been applied to a broad range of problems in various disciplines with remarkable success. They are particularly useful in settings where limited knowledge about the problem is available (black-box optimisation) and evaluating candidate solutions is the only means of learning about the problem at hand.

However, the reasons behind their success are often elusive: their performance often depends crucially, and unpredictably, on design choices and parameters. Furthermore, given a class of bio-inspired algorithms it is unclear on which kind of problems it performs well and on which it performs poorly.

In recent years theoretical analyses have emerged that provide results about the performance of bio-inspired algorithms. They rigorously estimate the expected time required by the algorithms to find a satisfactory solution for various optimisation problems. Such analyses use mathematical techniques drawn and extended from the fields of randomised algorithms, probability theory and computational complexity. The results allow for insights into the working principles of bio-inspired meta-heuristics, enable the assessment of parameter choices and design aspects, and ultimately guide towards the design of more powerful algorithms. This studentship offers a valuable opportunity to work within this very active, challenging and exciting field of research at the intersection between theoretical computer science, machine learning and artificial intelligence.

The successful applicant will perform high quality research in the area of time complexity analysis at the interface between bio-inspired computation and artificial intelligence. During the PhD studies, he/she will develop expertise in one or more promising research areas of his/her choice in this wide research area.

Possible topics include the performance analysis of:

a) Population-based meta-heuristics: highlighting their advantages over single-trajectory algorithms and/or the advantages of recombination over mutation-only algorithms
b) Algorithm configurators: how to evolve the optimal parameter settings for the meta-heuristic
c) Hyper-heuristics: how to evolve the meta-heuristic itself
d) Genetic programming: how to evolve computer programs effectively;

About the department / Research Group

The Department of Computer Science was established in 1982 and has since attained an international reputation for its research and teaching. In the 2014 Research Excellence Framework, 45% of the research in the department was recognised as internationally excellent in terms of originality, significance and rigour, and another 47% as internationally world leading. These results placed the department among the top 5 UK computer science departments for research excellence. The successful candidate will join the recently established and growing Algorithms group in the department with world-leading expertise in the theory of bio-inspired computation.

Key Words

Artificial Intelligence, Bio-Inspired Computation

Candidate Requirements

Applicants must have at least a 2.1 or above degree in Computer Science. Outstanding applicants from Mathematics, Physics and Engineering will also be considered and are encouraged to apply. The successful applicant must have excellent analytical and computational skills. He/She must be an excellent team player who can work independently and communicate well with others. If English is not their first language, they must have an IELTS score of 6.5 overall, with no less than 6.0 in each component.Since the project is theoretically challenging, strong mathematical and probability theory skills are required.

Funding and Eligibility

This Studentship will cover tuition fees at the UK rate and provide a tax-free stipend at the standard UK rate (currently £15,609 for 2021/22) for three and a half years. International students are eligible to apply, however will have to pay the difference between the UK and Overseas tuition fee. Funding is available for conference attendance and collaborative research visits to related organisations.