

Host Application to the SPECIES Research Internship Scholarship

Short CV of advisors

Professor Abdel Salhi (PI)

Professor in Operational Research, Department of Mathematical Sciences, University of Essex, UK

His interests are in Mathematical Programming, Nature-Inspired Algorithms and Evolutionary Computing, Algorithm Design, Analysis and Implementation on sequential and parallel/distributed platforms.

He has worked on a number of funded projects as a PI or Co-I. These include labour scheduling in container ports in collaboration with the Port of Felixstowe, predictive modelling of warranty claims in the automotive industry with MSXi, dynamic pricing for greener distribution in online retail with Ocado, data security in business and local government with the Data Research Centre of Essex University and others.

He has supervised successfully 18 PhD students and many more MPhil/MSc students. He has published over 100 journal and conference papers. His work appeared in Annals of OR, Journal of the OR Society, Journal of Algorithms and Computer Technology, Journal of Memetic Computing, Applied Soft Computing to name a few.

He has introduced, with Eric Fraga of UCL, the Strawberry Algorithm, generally known as the Plant Propagation Algorithm.

Dr. Xinan Yang (co-I)

Reader in Operational Research, Department of Mathematical Sciences, University of Essex, UK

Research Interests: *combinatorial optimization applications in Logistics, Transportation, Revenue management and Telecommunication. Rich algorithm development experiences in large scale MILP (Meta-heuristics) and Approximate Dynamic Programming.*

Oct. 2013 – Present Lecturer-> Senior Lecturer-> Reader in Operational Research, Essex

- Led/Co-led KTP projects (£235,222 with Mediterranean Shipping Company, £184,632 with Ocado Technology) funded by Innovate UK. Worked on various real-world combinatorial applications on **scheduling, packing, matching, timetabling** etc.
- Obtained IAA impact fund (£14,007, 2018) and the research on “**Dynamic pricing and emission control for e-grocery fulfilment**” won the award for Best Impact in Enterprise and Innovation.
- Supervised 6 PhD students (3 graduated, 2 in writing up) on combinatorial optimization problems via **Meta-heuristics, ADP, Reinforcement learning**.
- Published 13 articles in world-leading research journals, including EJOR, TS, CAOR, JORS, ANOR, ORSP etc.

Mar. 2012 – Oct. 2013 Senior Research Associate, Management School, Lancaster University, UK

Jun. 2007 - Oct. 2007 Research Internship, France Télécom R&D, Paris, France

Nov. 2007 - Dec. 2011 Ph.D. in Operational Research, School of Mathematics, University of Edinburgh, UK

Description of the research group

The Department of Mathematical Sciences (DMS) is a founding department of the University of Essex and is currently undergoing an exciting phase of positive transformation. Substantial recent investment from the University has supported an ambitious departmental growth strategy. These developments have been accompanied by a commensurate increase in research income (46% increase from 2014 to 2020). As recognition of this successful growth, in 2018 the Department moved to new, purpose-built accommodation within the University's flagship new £18M "STEM Centre", which provides cutting-edge new facilities and an **ideal working environment for research and collaboration**.

The Department currently comprises 42 academic staff, 2 senior research officers, 4 Knowledge Transfer Partnership (KTP) associates and 23 PhD students. DMS aims to deliver fundamental research across the areas of pure and applied Mathematics, Data Science with Actuarial Mathematics, **Operational Research and Optimisation**, and statistical methodology, whilst also leading novel interdisciplinary research, and working with industry and external stakeholders to deliver real world impact. Extensive interaction between themes and groups provides greater breadth of research, while **engagement with high profile institutional research centres** hosted at Essex, such as the Institute of Social and Economic Research (ISER), the Institute for Analytics and Data Science (IADS), and the UK Data Archive (UKDA), enable much wider interdisciplinary collaboration.

Research activity is structured across two main groups reflecting the department's dual focus on both statistical & data applications and fundamental mathematics: Data Science and Mathematics. **Operational Research (OR) and Optimization** is an important research theme under Data Science, which includes staff at all career stages, from three early career academics (Amanatidis, Meng, Maldonado), to a mid-career academic (**Yang, co-I**), through to an internationally acknowledged expert in nature-inspired heuristics (**Salhi, PI**). Theme members conduct multidisciplinary research in the broad areas of OR and mathematical modelling including linear and nonlinear programming, combinatorial optimization, deterministic and stochastic dynamic programming, algorithm (heuristics) design and analysis (including the novel Plant Propagation Algorithm (PPA) developed by **Salhi**), implementation of algorithms, data analytics and applications in portfolio selection, labour scheduling, green distribution, and predictive modelling.

Description of the work to be carried out by the student

Title: Classification and hybridising of Evolutionary Algorithms

Nature Inspired Algorithms (NIA's) and Evolutionary Algorithms (EAs) are efficient heuristic search methods inspired by natural phenomena such as evolution, with powerful characteristics of robustness and flexibility in tracking down optimum/near-optimum solutions of complex optimization problems. They are often population-based and stochastic in nature. EAs in particular have been successfully applied to a wide range of practical problems as arise in industrial/management sectors such as Logistic, Transportation, Energy, Telecommunication and etc.

Many NIA's bearing different names and being inspired by different natural phenomena are not significantly distinct in terms of their search processes. For example, the Lion algorithm (LA) [3] and the Artificial Bee Colony (ABC) algorithm [4] although different in context and terminology, are in fact similar. Same thing can be said of the Volcano Eruption Algorithm (VEA) [5] and the Fireworks Algorithm (FWA) [6]. However, the Artificial Bee Colony algorithm and the Ant Colony algorithms, although both inspired by social animals are in fact very different in philosophy and search process. The same thing can be said of the Plant Propagation Algorithm (PPA) [1] and the Runner Root Algorithm (RRA) [2], both inspired by the way the strawberry plant propagates.

The proliferation of NIA's is good as it shows our realisation that Nature has evolved efficient processes to solve problems not that different from ours; Tapping into this almost infinite store of ideas is a more than welcome endeavour. However, replicating existing work, or re-inventing the proverbial wheel is a waste of effort, the end of which can be misleading in many ways. For instance, embarking on the comparison of the "same" algorithm is wasteful; recommending one algorithm instead of another, when in fact they are the same is counter-productive etc.

Motivated by this fact, we aim to critically review all existing NIA's/EA's and provide a novel classification framework based on their technical specifications. A generic structure will be proposed and based on this structure methodologies will be put into classes according to their mathematical philosophy. A "family tree" of the algorithms will be built accordingly to highlight the differences between these approaches, which will also inspire new ideas on potential aggregation of approaches in similar categories by swapping certain steps in the same phase of implementation, and/or hybridisation of approaches in different categories to complement the entire search process. Upon successful investigation, future users of NIAs/EAs, especially industrial users who have limited understanding of the whole research background, will have a clearer view of all approaches so as to make a more informed choice of those that are most suitable for their own problems.

Reference

- [1] A.Salhi and E.S.Fraga, "Nature-Inspired Optimisation Approaches and the New Plant Propagation Algorithm," Proceedings of the ICeMATH'11, Yogyakarta, Indonesia, pp. K2-1:K2-8, 2011.
- [2] F.Merrikh-Bayat, "The Runner-Root Algorithm", Applied Soft Computing, Vol. 33(C), pp. 292-303, 2015.
- [3] B.R. Rajkumar, "The Lion's Algorithm: A New Nature-Inspired Algorithm, Procedia Technology, Vol. 6, pp.126-135.
- [4] D.Karaboga, and B.BAsturk, "Artificial Bee Colony (ABC) Optimization Algorithm for Solving Constrained Optimization Problems" in Advances of Soft Computin: Foundations of Fuzzy Logic and Soft Computing, Vol. 4529/2007, pp.789-798, 2007.
- [5] E. Hosseini, S.S. Ali, K.Z.Ghafoor, D.B. Rawat, M. SAif, X.Yang,"Volcano Eruption Algorithmfor Solving Optimization Problems," Neural Computing and Applications, 33, pp. 2321-2337, 2020.
- [6] Y.Tan and Y.Zu, "Fireworks Algorithm for Optimization," In Proceedings of Conference on Advances in Swarm Intelligence, First International Conference, Part I, ICSI, 2010

Other relevant information

Accommodation arrangements

Essex is a campus-based university which has a range of accommodation options to suit different needs, preferences and budgets, all within walking distance of the academic departments and campus facilities. The accommodation office will help the candidate to sort out the on campus accommodation, or provide information on private rentals/private students accommodations.

Location information

The candidate will work in the main campus at Colchester, Essex, East of England. Colchester is 50 miles (80 kilometres) northeast of London and is connected to London by the A12 road (50 minutes driving) and its railway station (45 minutes from London Liverpool Street) and is less than 30 miles (50 km) from London Stansted Airport.

The candidate will get a desk in the shared room for RAs and PhDs, in the new £18M STEM Centre where all DMS staff and PGR students work from. This will provide the candidate with excellent opportunities to networking with colleagues and other researchers.