

Research group: Edinburgh Napier University

The Nature Inspired Intelligent Systems group (NIIS) is one of two groups in the interdisciplinary Centre for Artificial Intelligence and Robotics.

The group takes inspiration from processes observed in natural systems to build computational systems that are capable of problem solving – tackling problems that range from optimising processes, through engineering design, to enabling groups reach socially beneficial outcomes, e.g. by reducing energy consumption. A number of members focus on combinatorial optimisation problems, with expertise in logistics (vehicle-routing), workforce scheduling, timetabling and packing. While in many applications, optimisation leads to considerable economic benefits, our work has a particular emphasis on reducing carbon emissions and sustainable travel. We combine evolution with machine-learning techniques to improve algorithm selection and develop optimisation systems that exhibit life-long learning, capable of automatic algorithm generation and improvement through application of genetic programming methods.

The group also does research in the area of robotics, using evolution as a tool to design and build novel robots for use in unknown-environments, and as a method to develop adaptive robot behavioural mechanisms, that enable robot(s) to remain fit-for-purpose in dynamically changing environments, and to collaborate to achieve tasks more efficiently. We work in both simulation and hardware, and have access to 3d printing facilities for creating autonomously designed robots. We have a small swarm-robotics laboratory onsite as well as access to space to run robotic experiments at the National Robotarium of Scotland, a short bus ride from the university.

Staff available for hosting:

Emma Hart

Prof. Hart's research lies in the area of optimisation and learning. Her work falls into two main areas. (1) Development of Optimisers for combinatorial optimisation domains that “keep learning”, i.e. are able to adapt to changing characteristics of instances, improve with experience of solving problems, and autonomously adapt to unknown domains. This requires advances in instance-generation, automatic configuration/selection and algorithm generation as well as methods to detect change. (2) Evolutionary Robotics, particularly in the joint optimisation of morphology and control, and the hybridisation of machine-learning/reinforcement learning techniques for rapid learning. She is EiC of the MIT Press Journal Evolutionary Computation. Her work in Evolutionary Robotics has attracted significant media attention, including a recent TED talk and in national media.

Kevin Sim

Kevin Sim is a Lecturer in Computing Science. He holds a PhD from Edinburgh Napier University in Hyper-Heuristics. Before commencing his current employment as a lecturer in computing science he worked for 3 years as a research fellow working on an EPSRC funded project entitled Real World Optimisation with Life-Long Learning. His research interests lie in hyper-heuristics applied to real world problems including logistics, and optimisation; algorithm selection and automated algorithm generation for optimisation and learning, specifically in the area of combinatorial optimisation. He was Co-author of the Best Paper in the ECOM track at GECCO 2019 and Winner of the Humies Bronze Medal along with Prof. Hart at GECCO 2018.

Leni Le Goff

Léni K. Le Goff is a lecturer in machine learning and artificial intelligence at Edinburgh Napier University. He obtained his Ph.D. of Computer Science and Robotics in 2019 at ISIR (Institute of Intelligent Systems and Robotics), Sorbonne University, in Paris. And he received an engineering degree in Computer Science in 2014 from ENSIIE (École nationale supérieure d'informatique pour l'industrie et l'entreprise). His first research experience was in 2013 when he participated in the International Genetically Engineered Machine (IGEM) competition as a computer scientist for biological system modelisation. Then, he worked as a Ph.D. student in the European-founded developmental robotic project DREAM between 2015 and 2019. Finally, as a research assistant at Edinburgh Napier University, he contributed to the EPSRC-funded project Autonomous Robotic Evolution between 2019 and 2022. His research focuses on using machine learning and artificial intelligence to increase the adaptability and autonomy of robotic systems. He also *studies the automatic design of robots using artificial evolution*.

Neil Urquhart

Neil Urquhart is a Lecturer. His research applies meta-heuristic methods to combinatorial optimisation problems, with a particular interest in logistics based domains. He recently published a book “*Nature Inspired Optimisation for Delivery Problems: From Theory to the Real World*. Springer Nature” on this subject. His recent work focuses on the use of Quality-Diversity algorithms to produce repertoires of solutions that are diverse with respect to user defined characteristics, therefore providing an end-user with some choice. He is particularly interested in logistics problems in which the goal is to reduce the carbon-footprint associated with a delivery, by including this in a multi-objective formulation.

Kehinde Babaagba

Kehinde is a lecturer. She obtained her PhD from ENU in 2021. Her work combines evolutionary algorithms and machine-learning for malware detection, particularly related to metamorphic malware. She is interested in the use of EA/Quality-Diversity methods to produce new malicious samples to create additional training data, and in the use of Evolutionary Generative Adversarial Networks (GANs) to achieve this.

Potential Projects

1. Algorithm Selection for meta-heuristics, leveraging a range of machine-learning approaches [Sim, Hart].
2. Quality-Diversity methods for instance generation; evolution of algorithm portfolios which exhibit diversity of behaviours; producing diverse instance to combinatorial optimisation problems in logistics [Urquhart, Hart].
3. Lifelong learning in optimisation: methods for continual adaptation of algorithms based on problem-solving experience, i.e. learning from experience or dealing with streaming instances that change over time [Hart]
4. Dynamic sampling strategies for meta-heuristic approaches operating on noisy objective functions to reduce computational budget [Le Goff]
5. Joint optimisation of robot body and control via evolution and learning [Le Goff, Hart]
6. Adaptive learning strategies to enable adaption of robot controllers to unknown environments [Le Goff, Hart]
7. Improve detection of metamorphic malware [Babaagba]

About the university and the city

Now home to over 19,500 students from over 140 countries, Edinburgh was officially inaugurated as a University in 1992., However our story goes back to the time of John Napier, the brilliant 16th- century mathematician and philosopher from whom we take our name and whose original residence now forms an integral part of our Merchiston Campus (one of 3 campuses spread around the city). The School of Computing is located at Merchiston, in the south-west of the city, an area renowned for its many cafes and restaurants and a short walk from the city centre. Edinburgh. It's probably one of the few cities in the world to have an extinct volcano in its centre, and is known world-wide for hosting a unique range of festivals, including the Edinburgh Fringe, an International Science Festival and an annual Jazz and Blues Festival.