Acadamh Ríoga na hÉireann
Royal Irish Academy

Charlemont grant report

Recipient name:	Dr Karl Mason
Discipline and subject area:	Sciences
Amount and year awarded:	€2,484.94 in 2022
Title of project:	Evolving Multi-Objective Robot Swarms (EvoMORS)

Summary of findings:

This research proposed an evolutionary multi-objective (MO) neural network (NN) for robot swarm control. The MO NN was evolved using a low-fidelity Python simulator in an environment with 3 robots. The controller was then tested in a high-fidelity simulated environment developed using Webots. The MO NN controller was then evaluated for larger numbers of robots.

The primary findings of this research are:

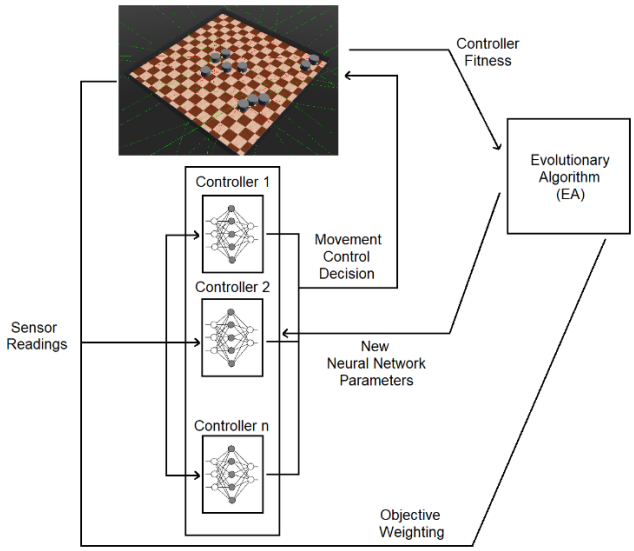
1) It was demonstrated that the evolved Multi-Objective Neural Network (MO NN) is an effective approach for controlling robots in a swarm in the presence of multiple objectives. As the weightings for each objectives were varied, the robots adjusted their behaviour to account for the preference for each objective. The velocities and distances to the origin during simulation were significantly different (p value <1%) when comparing a maximum weighting for each objective.

2) MO NN evolved in a low-fidelity simulator can be transferred to a high-fidelity simulator and exhibit similar behaviour. This is because the low-fidelity simulator can replicate the relevant features of the high-fidelity simulator, specifically sensor input, decision making and updates to robot positions. This approach is therefore recommended to reduce the computational cost associated training NN controllers. This indicates that the evolved MO NN controllers are robust to environmental changes.

3) The MO NN evolved in a low-fidelity simulated environment with 3 robots scales well when tested in a high-fidelity simulated environment with 10 robots. No further NN training is required. This is a key advantage of the proposed evolutionary MO NN approach as opposed to MO path planning.

Impact:
This work will impact researchers applying machine learning to robotics in general as it demonstrates the transferability of control policies developed in a low-fidelity simulator to a high-fidelity simulator.

This work will also impact robotics research in areas that consist of multiple objectives, e.g., path planning.



Plans for continuing collaboration:

A research paper has been prepared as a result of this successful collaboration. Future work would involve applying the developed neural network robot controllers to the DOTS simulator in the Bristol Robotics Laboratory (BRL). Further funding would need to be obtained to fund a more long-term visit to the BRL in order to achieve this. I intend to apply for further funding to support future collaborations from the ERC.

Published work and publication plans:

A paper has been written based on the research conducted in this project. This paper is currently under review for the 26th International Conference on the Applications of Evolutionary Computation. A preprint of this paper can be provided upon request.

Dissemination and plans for future dissemination:

This work has been/will be disseminated in multiple ways:

• The work will be presented at the 26th International Conference on the Applications of Evolutionary Computation, if it is accepted into the conference.

• The findings of the research were presented at an invited talk which I delivered at the Bristol Robotics Laboratory in June 2022.

Collaborations and planned collaborations:

This project involved a collaboration with the Bristol Robotics Laboratory. There were no additional academic/industrial collaborators involved with this project. It is hoped that future projects would involve participation from a larger number of collaborators.

Outreach and engagement activities:

During a recent University of Galway open day, I gave a talk to prospective IT students to encourage them to study IT at the University of Galway. As part of this talk, I discussed ongoing research projects within my research group at the School of Computer Science. I displayed a short video demonstrating the behaviour of the robot swarm when controlled using the Multi-Objective Neural Network controllers developed in this project. The students in attendance were very interested by this. In addition to this, a brief description of the EvoMORS project is provided on my publicly accessible research website: (https://karlmasonsite.wordpress.com/projects/). The support provided by the Royal Irish Academy that has enabled me to complete this project has been acknowledged in all instances to research dissemination and communication.