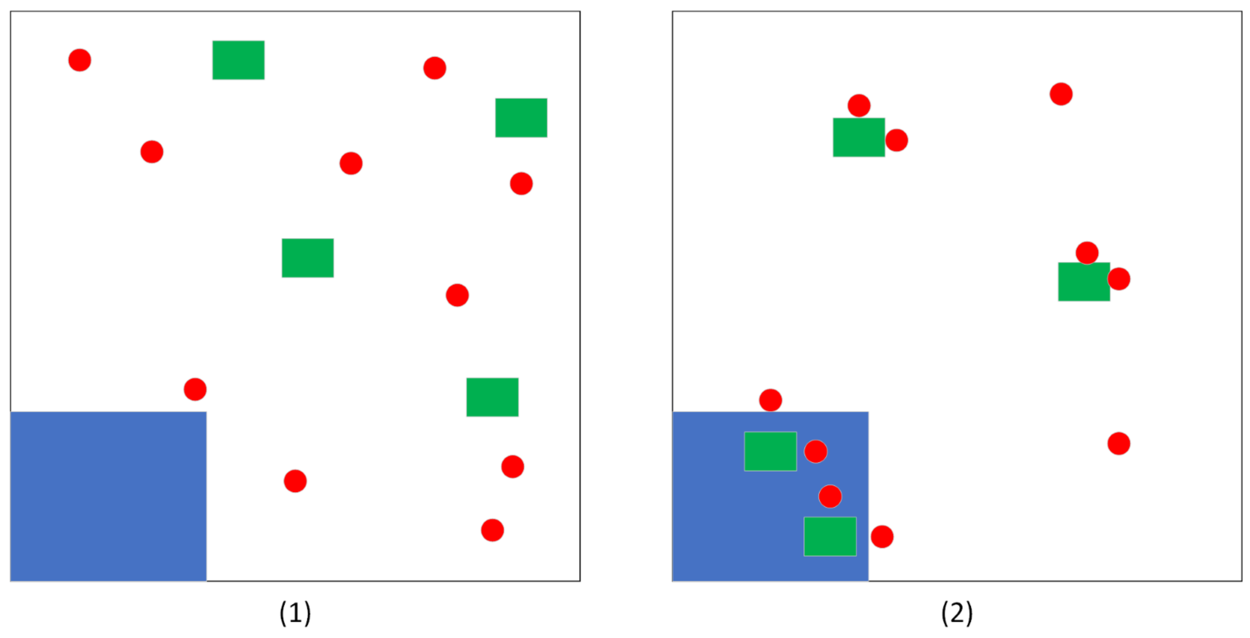
Evolving problem-solving collective behaviour and functional diversity in swarm robotics

Project Overview

Swarm robotics is a complex and constantly evolving field. It is an application of swarm intelligence which follows the behaviours of a group of interacting agents. These agents have behavioural and functional diversity, which helps the swarm in accomplishing their tasks. However, an issue with swarms is that they must be heavily configured for environments to be effective at their tasks, thus the problem of using robotic swarms in unknown environments. A solution to this is the use of evolutionary algorithms to evolve the swarms and allow them to adapt easily to unknown environments.

Project Objectives

The primary research objective for this project is determining the best method for evolving problem-solving collective behaviour and functional diversity in swarm robotics. To do this we each took the mEDEA method, which is an evolutionary algorithm that deals with environment adaptation, and used it as base, combining it with other behaviour-based evolutionary methods to form hybrid methods. The three hybrid methods (shown below) were then compared against mEDEA in a collective gathering task (shown in figure to the right) of various difficulties:



1 MAP-Elites

MAP-Elites is a quality diversity algorithm that creates a diverse collection of behaviours. We define a set of performance measures to determine the robot design and create an N-dimensional vector of interests to evaluate the robot. High-performing individuals are selected and used for our next generation of robots.

2 Novelty Search

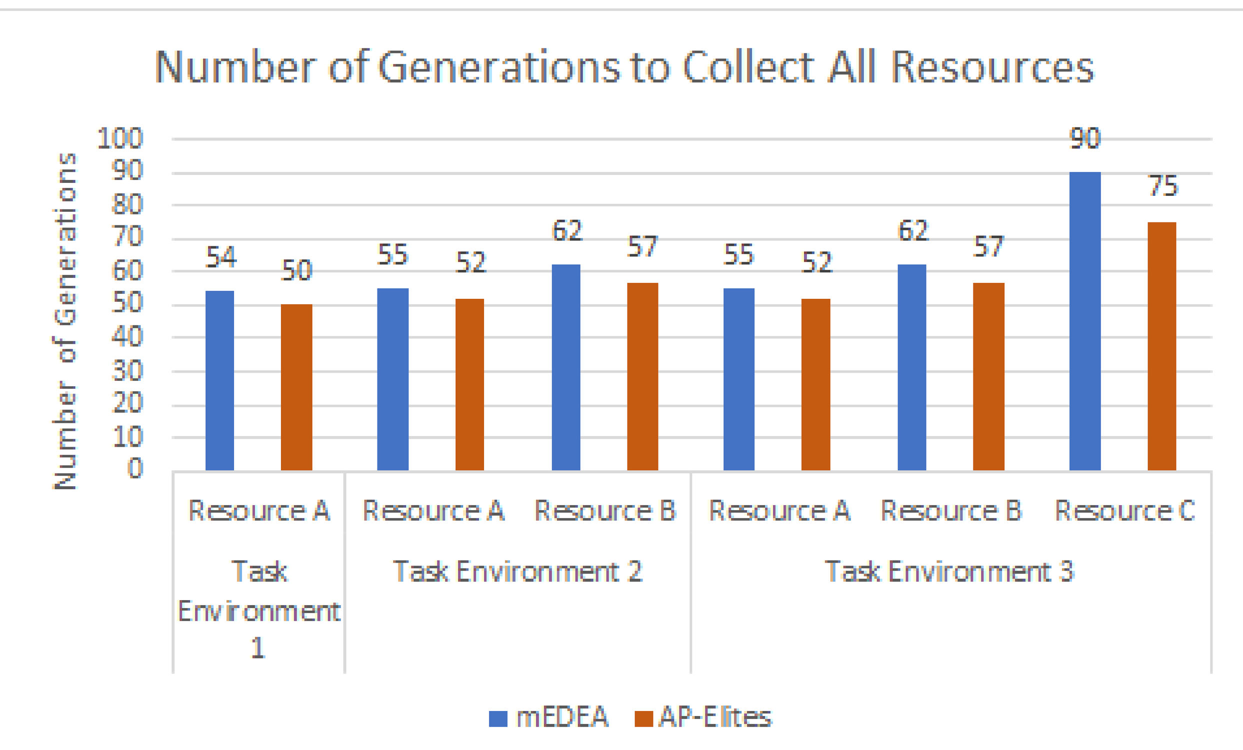
Novelty Search is an evolutionary algorithm that promotes passing on robot behaviour that is atypical or abnormal from the rest of the swarm. This uses a more lateral approach to solving problems with deceptively complex solutions.

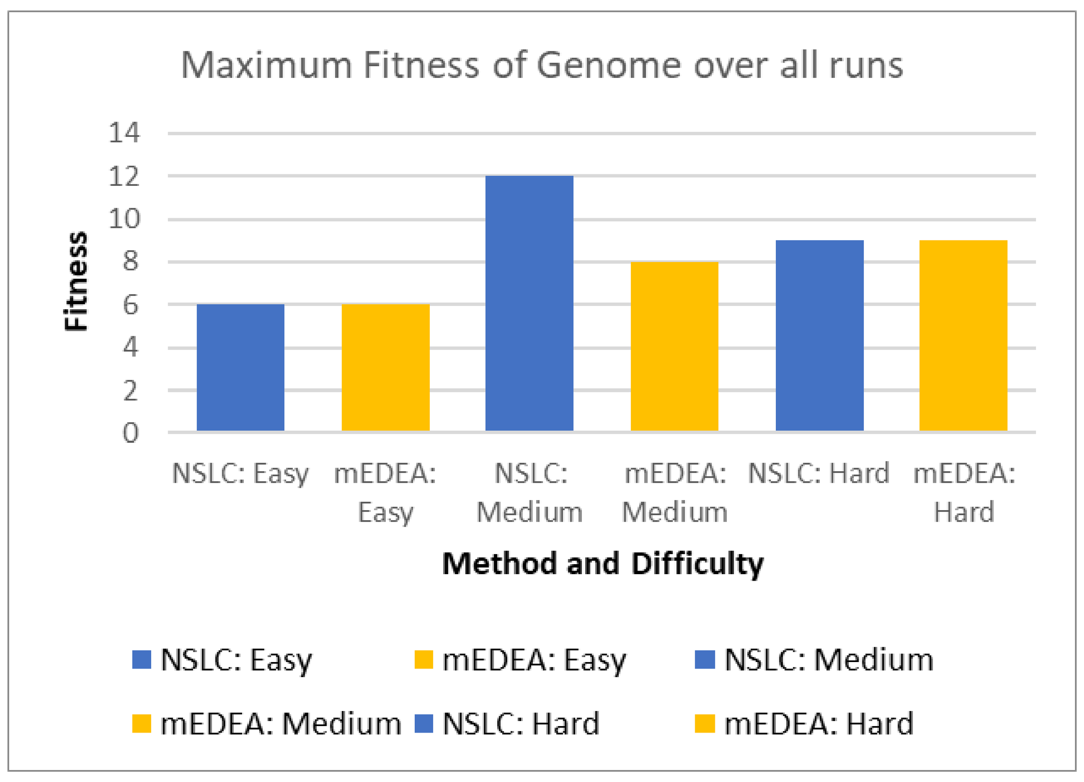
3 Novelty Search with Local Competition (NSLC)

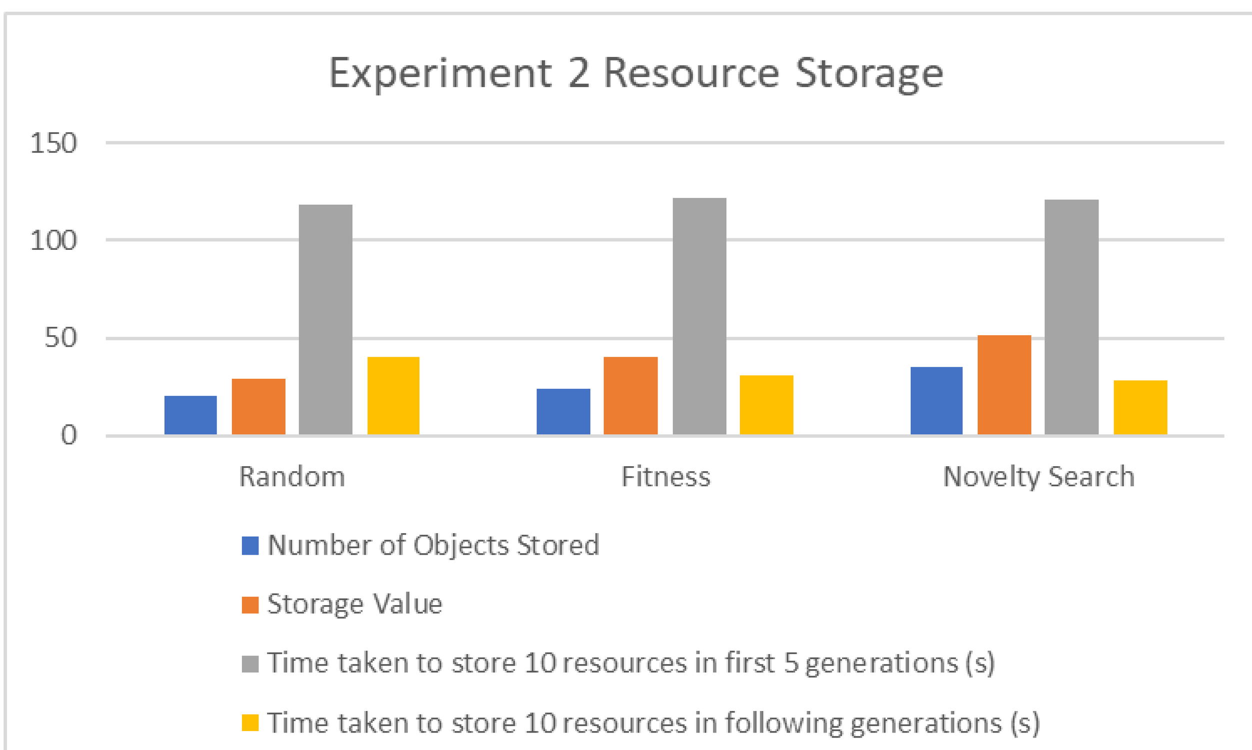
NSLC expands on novelty search by adding local competition where agents which have similar behaviours will compete against one another. This allows NSLC to have a high diversity while still having high performing solutions.

Results

Across the experiments conducted with each of the 3 hybridizations, no statistically significant difference was observed in the robots' ability to efficiently adapt to the environment whilst completing the main objective of foraging resources compared to the base mEDEA algorithm. Three graphs showing the results from some of our experiments are shown below although all three hybridized methods had similar results like these. The hybridized methods still matched mEDEA and we feel further research could go into testing these hybrid methods in more complex tasks such as collective construction.







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