Selection Pressures in Evolutionary Computation

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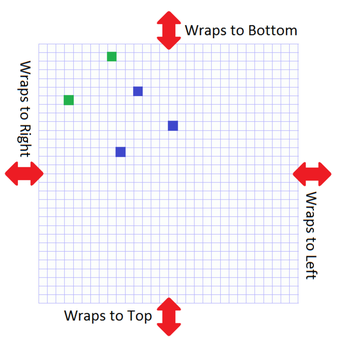
Abstract

Previous research using evolutionary computation indicates that team composition (homogeneous vs heterogeneous) and the level of selection (team vs individual) have a strong impact on the ability of evolved teams to exhibit teamwork in challenging tasks [1]. However, this previous research only made use of a single objective per evolved population. In contrast, when a multi-objective evolutionary algorithm is used, populations can be subject to multiple individual and team-level objectives as well as combinations of the two. This poster explores the performance of genetically homogeneous and heterogeneous teams of predators with various levels of selection against scripted prey agents in a torus-shaped grid world. Results demonstrate that evolution involving team and individual selection simultaneously encourages positive team behavior as well as independent population success, leading to better overall performance.

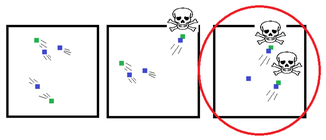
Predator-Prey Domain

- Three predators and two prey in a torus-shaped grid world [2]
- Torus-shaped grid world: agents can exit on one side of the grid world and wrap around to the opposite side
- Predators attempt to catch prey (occupy same location)
- Predators evolved against robotic/scripted prey
- Predator performance depends on different combinations of fitness functions:
  - o Minimize Trial Duration
  - o Minimize Distance from Prey
  - o Maximize Number of Prey Caught
- Predators with higher fitness scores move on to breed in the next generation while predators with lower fitness scores die out

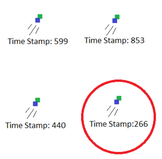
Torus Grid World



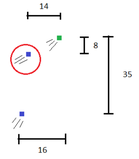
Maximize Number of Prey Caught



Minimize Trial Duration

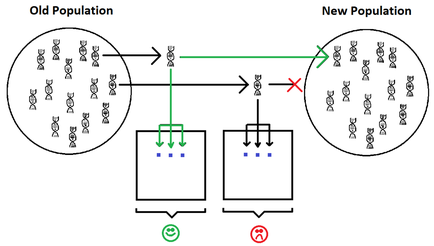


Minimize Distance from Prey

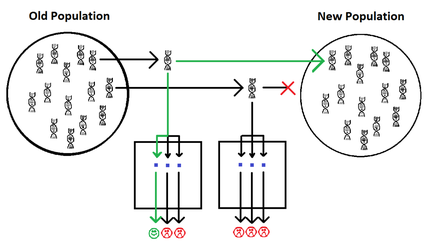


Team Composition and Level of Selection

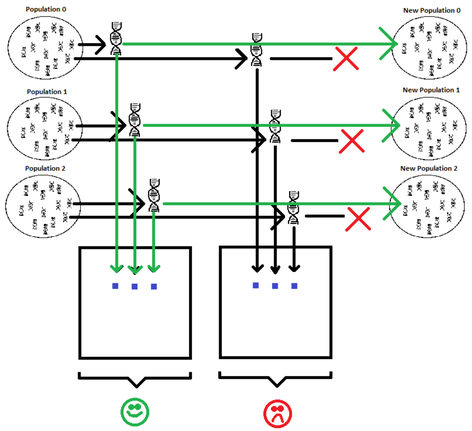
Homogeneous Team Selection



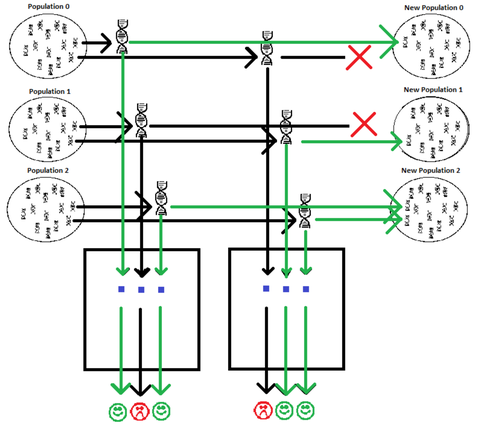
Homogeneous Individual Selection



Heterogeneous Team Selection



Heterogeneous Individual Selection



Homogeneous Vs Heterogeneous Teams

Homogeneous experiments use a single population of genotypes, each of which creates a neural network (the artificial brain of an evolving agent) that is then copied into each of the predator agents. Heterogeneous experiments use a separate population of genotypes for each agent, meaning that each agent has its own distinct neural network. Homogeneous teams allow for complex evolved behavior suitable for tasks that do not require any behavioral specialization. Heterogeneous teams can exhibit more specialized behavior and generally perform better in tasks that require different roles.

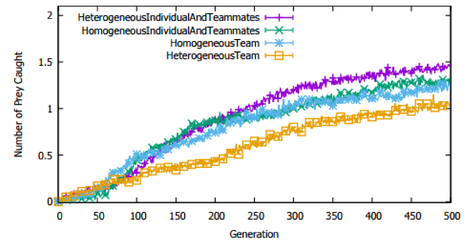
Selection

Selection is performed on each population individually by choosing the individuals with the highest fitness scores. Fitness functions can reward individual behavior (individual selection), behavior of the entire team (team selection) or both.

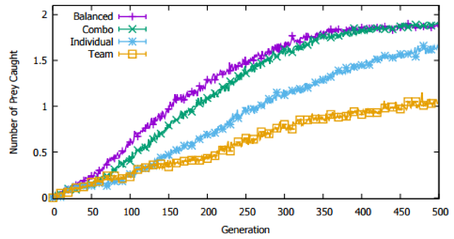
Results

- Predators were evolved against robotic prey with 100 neural network genotypes in each population
- 500 generations per experimental run
- 10 experimental runs for each team composition and level of selection
- Each agent was evaluated 10 times per generation and scores were averaged across trials

Average Number of Prey Caught by Best Team for Various Team Compositions



Average Number of Prey Caught by Best Heterogeneous Team for Various Levels of Selection



- Heterogeneous teams using individual objectives performed the best even if they also used team objectives. They also showed more complex, specialized behavior, including:
  - o All predators focus on the same prey agent(s) at the same time
  - o Predators designate one predator as a blocker
  - o Predators herd the prey towards the blocker
- Teams with individual selection performed better than those with team selection, but teams with both types of selection at the same time performed the best

References

[1] M. Waibel, L. Keller, and D. Floreano. Genetic Team Composition and Level of Selection in the Evolution of Cooperation. In *IEEE Transactions on Evolutionary Computation (Volume:13 , Issue: 3)*, June 2009.

[2] A. Rawal, P. Rajagopalan, and R. Miikkulainen. Constructing Competitive and Cooperative Agent Behavior Using Coevolution. In *IEEE Conference on Computational Intelligence and Games (CIG 2010)*, Copenhagen, Denmark, August 2010.

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