Optimizing Swarm intelligence and Neural Network through symmetric based approach

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Abstract

Swarm robotics, inspired by the collective behaviours of biological systems, such as social insects, facilitate complex feats through self-organisation based on very simple and local interactions between members. In this paper, we advocate the use of symmetry-based approaches as a general technique for boosting performance and robustness of systems in swarm robotics. Our approach explores the power of looking for symmetry in swarm systems to achieve greater efficiency and coordination. Using symmetry in communication topologies, task allocations, formation control, motion planning and sensing can have dramatic improvements on swarm behaviour. Symmetric communication topologies increase the homogeneity of the information flow, by eliminating information bottlenecks. Symmetric task allocations can make sure that the workload is fair among the members of a swarm, and symmetric movement patterns increase the smoothness of motion and alleviate collisions. Symmetric formation control improves stability; symmetric sensing can overcome sensing asymmetries to increase redundancy. Furthermore, symmetric redundancy and fault tolerance can increase the resilience with respect to failures. By showing a few examples of designs and theoretical analyses, we advocated for the use of symmetry-based approaches in swarm robotics. This is important because swarms can hardly perform complex tasks if they are not well coordinated, and symmetry-based approaches for swarm robotics offer tremendous benefits in easing the control and design of swarm robotic systems thanks to their properties of homogeneity and balance. The main benefits of symmetry-based approaches include adaptivity, energy efficiency and scalability.

1. Introduction

Swarm robotics, inspired by the collective behaviors of natural systems like ant colonies, bee hives, and fish schools, is an innovative approach in robotics. It uses decentralized coordination and cooperation among many autonomous agents to solve complex tasks that are difficult for individual robots. This method has shown great promise in various fields such as: