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Editorial

Distributed learning algorithms for swarm robotics

Swarm robotics is a relatively new approach to control the operation of a multi-robot system, which consists of a large number of physically simple robots. In this context, the robots dispose of limited sensing and acting resources. It is well known now that from such systems and with the right control actions, the desired collective behavior emerges from the interactions between the robots of the swarm and their interactions with the environment. This property is usually identified as swarm intelligence. The control actions (algorithms) are usually simple, and in most cases, inspired form biological systems such as ants colonies, bird flocks, fish schools and/or social as well as economic systems, among and other existing fields, where the swarming behavior occurs.

The focus of this special issue to be published in Elsevier Journal on Neurocomputing will be on all aspects of efficient distributed control of robot swarms, and mainly distributed and learning algorithms for swarm robotics, to solve operational problems to manage the swarm, such as clustering, dynamic task allocation, and localization. Applications to solve real-world problems, especially those dedicated to nano-robotics, are also welcome.

This special issue of Neurocomputing is dedicated for all aspects of efficient distributed control of robot swarms, and mainly distributed and learning algorithms for swarm robotics, to solve operational problems to manage the swarm, such as clustering, dynamic task allocation, and localization. The papers were peer reviewed by outstanding researchers in this field. We are very grateful to them for their valuable suggestions. The contributions of each of the selected papers are summarized as follows:

First, in a paper entitled *A Review of Swarm Robotics Tasks*, the author reviews the set of main tasks essential to operate a group of autonomous robots that aims at solving a problem using a distributed approach. He illustrates many used algorithms, which have been used to face the challenges imposed during the execution of each task. Aggregation, flocking, foraging, object clustering and sorting, navigation, path formation, deployment, collaborative manipulation and task allocation problems are described in detail. For each of the main tasks, the swarm design methods are identified, the past works are categorized into task-specific based classification and mathematical models and performance metrics are described.

Thereafter, in a paper entitled *Distributed Efficient Localization in Swarm Robotic Systems Using Swarm Intelligence Algorithms*, the authors propose a distributed algorithm for the localization problem, which arises from the need of robots of a Swarm Robotic System or even nodes of a wireless sensors network, to determine their positions without the use of external references, such as the Global Positioning System. Targeting a more accurate solution of the localization problem, we propose a new multi-hop method. Two overall algorithms are developed to work with the proposed method: the first one is based on the Particle Swarm Optimization algorithm, and the second based on the Backtracking Search algorithm.

Subsequently, in a paper entitled *Formation Control Using Replicator–Mutator Dynamics for Multiple Mobile Autonomous Agents*, the authors propose a leader–follower formation control algorithm based on replicator–mutator dynamics and complex Laplacian. The networked multi-agent system is composed of a swarm of mobile autonomous agents keeping the intended formation. Replicator–mutator dynamics are used to reach consensus of the formation, to guarantee a faster convergence and to avoid potential collisions between the robots of the swarm.

Then, in a paper entitled *Efficient Distributed Algorithm of Dynamic Task Assignment for Swarm Robotics*, the authors propose a simple yet efficient distributed control algorithm to implement dynamic task allocation in a robotic swarm. In this algorithm, each robot that integrates the swarm runs the algorithm whenever it senses a change in the environment. At each execution, the robot receives messages for the robots of the swarm about the tasks they assigned to themselves and attempts to deduce the right task it should assign to itself, backed by some interpolation of the received information.

After that, in a paper entitled *History-Driven Particle Swarm optimization in dynamic and uncertain environments*, the authors report on a novel multi-population particle swarm optimization, which improved its performance by employing an external memory. This algorithm, namely History-Driven Particle Swarm Optimization, uses a BSP tree to store the important information about the landscape during the optimization process. Benefiting from the content of this memory, the algorithm can approximate the fitness landscape before actual fitness evaluation for some unsuitable solutions.

Last but not least, in a paper entitled *Binary Gray Wolf Optimization Approaches for Feature Selection*, the authors propose a novel binary version of the gray wolf optimization, which simulates the hunting process of gray wolves in nature. The

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proposed technique is explored to select optimal feature subset for classification purposes.

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