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Editorial

Editorial: Special Issue "Swarm Robotics"

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Swarm robotics is the study of how to coordinate large groups of relatively simple robots through the use of local rules so that a desired collective behavior emerges from their interaction. The group behavior emerging in the swarms takes its inspiration from societies of insects that can perform tasks that are beyond the capabilities of the individuals. The swarm robotics inspired from nature is a combination of swarm intelligence and robotics [1], which shows a great potential in several aspects. The activities of social insects are often based on a self-organizing process that relies on the combination of the following four basic rules: Positive feedback, negative feedback, randomness, and multiple interactions [2,3].

Collectively working robot teams can solve a problem more efficiently than a single robot while also providing robustness and flexibility to the group. The swarm robotics model is a key component of a cooperative algorithm that controls the behaviors and interactions of all individuals. In the model, the robots in the swarm should have some basic functions, such as sensing, communicating, motioning, and satisfy the following properties:

1. *Autonomy*—individuals that create the swarm-robotic system are autonomous robots. They are independent and can interact with each other and the environment.
2. *Large number*—they are in large number so they can cooperate with each other.
3. *Scalability and robustness*—a new unit can be easily added to the system so the system is easily scalable. More number of units improve the performance of the system. The system is quite robust to the losing of some units, as there still exists some units left to perform. However, in this instance, the system will not perform up to its maximum capabilities.
4. *Decentralized coordination*—the robots communicate with each other and with environment to take the final decision.
5. *Flexibility*—it requires the swarm robotic system to have the ability to generate modularized solutions to different tasks.

Potential applications for swarm robotics are many. They include tasks that demand miniaturization (nanorobotics, microbotics), like distributed sensing tasks in micromachinery or the human body [4]. They are also useful for autonomous surveillance and environment monitoring to investigate environmental parameters, search for survivors, and locate sources of hazards such as chemical or gas spills, toxic pollution, pipe leaks, and radioactivity. Swarm robots can perform tasks in which the main goal is to cover a wide region. The robots can disperse and perform monitoring tasks, for example, in forests. They can be useful for detecting hazardous events, like a leakage of a chemical substance. Robotics is expected to play a major role in the agricultural/farming domain. Swarm robotics, in particular, is considered extremely relevant for precision farming and large-scale agricultural applications [5]. Swarm robots are also useful in solving problems encountered in IoT (Internet of Things) systems, such as co-adaptation, distributed control and self-organization, and resource planning management [6].

This special issue on Swarm Robotics focuses on new developments that swarm intelligence techniques provide for the coordination distributed and decentralized of a large numbers of robots in multiple application fields. A collection of 15 papers has been selected to illustrate the research work and the experimental results of the future swarm robotics in real world applications. The papers of this special issue can be classified into the following three research areas:

Formation control and self-assembly methods: The papers belonging to this area present control algorithms to allow a fleet of robots to follow a predefined trajectory while maintaining a desired spatial pattern. Jian Yang and their colleagues introduce a limited visual field constrained formation control strategy inspired by flying geese coordinated motion [7]. Additionally, the methods proposed in [8,9] can reconfigure the group of robots into different formation patterns by coordinating, also in a decentralized way, the joint angles in the corresponding mechanical linkage. A self-reconfigurable robotic system that is capable of autonomous movement and self-assembly is introduced in [10]. The formation problem of multiple robots based on the leader–follower mechanism is investigated in [11]. A model based on Swarm Chemistry is used in [12] to investigate as interesting patterns can be detected. Finally, a three-dimensional (3D) model identification method based on weighted implicit shape representation (WISR) is proposed in [13].

Localization and search methods for UAV and drone swarms: This special issue presents papers to define the position information of the robot members in the system and real-time search to cover a broad search space. In [14], an algorithm for UAV path planning based on time-difference-of-arrival (TDOA) is proposed. In [15], the authors propose a decision-control approach with the event-triggered communication scheme for the problem of signal source localization. The authors of [16] present a novel search method for a swarm of drones—a PSO algorithm is used as mechanism to update the position. Furthermore, in [17], an integrated algorithm combining the potential field and the three degrees (the dispersion degree, the homodromous degree, and the district-difference degree) is proposed to deal with cooperative target hunting by multi-AUV team in a surface-water environment. Another search algorithm based on a multi-agent system with a behavioral network made up by six different behaviors, whose parameters are optimized by a genetic algorithm and adapt to the scenario, is present in [18].

Intelligence techniques for solving optimization problems. An algorithm inspired by the process of migration and reproduction of flora is proposed in [19] to solve some complex, non-linear, and discrete optimization problems. An additional parallel technique for meta-heuristic algorithms designed for optimization purposes is presented in [20]. The idea was based primarily on the action of multi-threading, which allowed placing individuals of a given population in specific places where an extreme can be located. Finally, a distributed hybrid fish swarm optimization algorithm (DHFSOA) designed in order to optimize the deployment of underwater acoustic sensor nodes has been proposed in [21].

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