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Brief Review on Formation Control of Swarm Robot

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Abstract— **This paper presented review formation control of swarm robot. Recently the problems formation control of swarm robots has attracted much attention, and several formation control schemes were proposed based on various strategies. The formation control strategies to solved these problem on swarm robots, with considering regulation concept in control theory. Swarm intelligence algorithms takes the full of advantages of the feature of swarm robotics, and provides a great solution for problem formation control on swarm robots.**

BACKGROUND

Swarm robotics is a new approach to the coordination of large numbers of relatively simple robots [1], that are autonomous, not controlled centrally, capable of local communication and operates based on some sense of biological inspiration [2]. Swarm robotic research is often inspired from biological systems such as insect colonies [3][4], flocks of birds [x], schools of fish [5], groups of amoeba [x], bacteria colonies [6], and cells in human or animal bodies [xx]. The incredible creativity of nature is an immense source of inspiration for solving problems real-world on swarm robots.

The real-world applications in swarm robots such as, military [6], inspect of blades in a jet turbine [7], oil absorbing [8], hazardous waste cleanup [9], search and rescue [10], security [11], industrial and household maintenance, construction [12]. The applications to solve these tasks was very complicated. To solved these tasks have been proposed by the swarm robotics researchers, such as foraging and coverage, flocking and formation, traffic control and path planning, etc [13].

The flocking problem could be viewed as a subcase of the formation control problem. Which one, formation control is one of the most important research areas for swarm robot applications because generally it is required a coordination control to obtain a strategic displacement to achieve a common work [14][15]. Such problems as initialization of formation, formation keeping, avoiding static or dynamic moving obstacles, and coordination between robots to resolve a specific task or to deal with obstacles remain important issues in robotic formation control [16].

Recently, formation control problems of swarm robots have attracted much attentions, and several formation control schemes were proposed based on various strategies for example, feedback linearization [17], behavior-based [16], leader-follower [18], virtual structure [19][20], potential function approaches [21][22][23][25], and extremum seeking control [26] [27]. Other formation approaches have also been reported in the recent literature, such as a synchronization approach, graph theory based method and path planning.

In behavior-based approaches is suitable for controlling a swarm of robots. The main problem of this approach is that it is difficult to analyze the overall system mathematically to gain insights into the control problems [16]. It is also not possible to show that the system converges to a desired formation.

In virtual structure approaches, the robot swarm is considered as a single rigid robot and a rigid geometric relationship among group members is maintained [20]. The formation in this approach is very rigid as the geometric relationship among the robots in the system must be rigidly maintained during the movement. Hence, it is generally not possible for the formation to change with time, and obstacle avoidance is a problem. The virtual structure approaches are not suitable for controlling a swarm robotics because the constraint relationships among robots become more complicated [25].

The potential field-based approach has been considerably used for controlling a large group of robots because of its advantage in controlling the robot swarms such that individuals stay together as a whole without collision. However, the potential field-based method has difficulty in driving the robot swarms to form specific desired shapes, and selecting potentials to achieve global convergence is also difficult.

In extremum seeking, it is a popular adaptive control technique (C.Zhang, Book ESC) . When source seeking is performed using a swarm robotics, the problem may become mathematically equivalent to swarm tracking. In swarm seeking, at least part of the potential function is assumed unknown, and is maximized or minimized collectively by the swarm . In this case, the maximization or minimization results in the localization of the unknown source, while also for instance attaining and maintaining a desired formation.

The many complex task of formation control of swarm robot, be required algorithms problem-solving which be able to provides increased performance, flexible, efficiency, and scalability as well as robustness. A swarm robotics algorithm must fit and make full use of the feature of swarm robotics. The algorithm should explore the cooperation between robots and share some features with swarm robotics system.

Swarm intelligence and bio-inspired algorithms takes the full of advantages of the feature of swarm robotics, and provides a great solution for problem formation control on swarm robots. Though not all of them are effcient, a few algorithms have proved to be very efficient and thus have become popular tools for solving real-world problems. Some algorithms are in sufficiently studied. The purpose of this review is to present a relatively comprehensive list of all the algorithms in the literature, so as to inspire further research

CURRENT RESULTS

The most important requirements of a formation control strategy are convergence to the desired formation and collision avoidance. In that case, in order to achieve convergence to the desired formation the robots must start their motion with an initial configuration that is in the attraction region of the desired configuration. Nevertheless, the dynamics can get stuck at a local minimum and the convergence to a global minimum cannot be guaranteed. To reduce local minima and accelerate convergence the swarm robot swarm intelligence need to solve the problem in the formation control.

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