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Pattern Recognition Approach for Formation Control for Swarm Robotics Using Fuzzy-Kohonen Networks

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Abstract. Recent advances in robotics have started making it feasible to deploy large numbers of inexpensive robots for tasks such as surveillance and search. However, coordination of multiple robots to accomplish such tasks remains a challenging problem. This paper describes new algorithm Fuzzy-Kohonen Networks (FKN) to achieve real-time reactive formation control for swarm robots.

BACKGROUND

A single robot suited for small scope applications such as CNC machines, robotic surgery, or serial manipulators. The system need a highly complex and very expensive control system to solve a real world requirements. However, it's performance can decrease when work in distributed applications in large and diverse environments such as search and rescue, surveillance operations, search and exploration, monitoring, and survey and mapping [1]. For solving such tasks in distributed applications, cooperation and coordination of multiple intelligent agents named swarm robots is required.

Currently, many researchers have turned to distributed solutions as opposed to centralized ones for reducing cost and complexity of autonomous systems. Swarm robotics system is a new approach of the large numbers coordination of relatively simple robots. To perform their tasks through local sensing of neighborhood and they haven't group leadership and global information [1][2].

The swarm robotics system is a growing field that emphasizes the coordination and the cooperative of a robot group. Especially, in the research area of formation control for swarm robots, the execution of several complex tasks have received much attention. To perform different types of tasks, oftentimes inspired by their biological counterparts. Pattern formation is sometimes considered as one of the steps of more complex distributed tasks [2][3]. However, swarms robots must perform that tasks without a designated leader, limited communication and simple algorithm.

Rather than equipping an individual robot with a control mechanism that enables it to solve a complex task on its own. Swarm robots usually controlled by simple strategies, but complex behaviors are obtained at the colony level by exploiting the interactions among the robots, as well as between the robots and the environment. Therefore, when designing swarm robotics system complex control algorithms is avoided, and instead principles such as locality of sensing and communication, homogeneity and decentralized, are followed [4]. This system entities that possess the ability to move within their environment, to interact with other robots, to perceive the information of the environment and to process this information.

In many control applications, a group of autonomous robots are required to follow a predefined trajectory while maintaining a desired spatial pattern. Moving in formation has many advantages over conventional systems, it can reduce the system cost, increase the robustness and efficiency of the system while providing redundancy, reconfiguration ability and structure flexibility for the system [5],[6]. However, the swarm robots have limitations in control strategy, due to their simple platform with onboard sensing and computational ability.

Formation control in unknown environment needs an approach that can deal with uncertain situation, where robustness properties must be intended in the control procedure. The control strategy in swarm robots formation must be simple algorithm with less computational ability, due to the onboard sensing and processing. Thus simple control strategy with limited processing speed and memory space is desirable.

To achieve real-time reactive formation control for swarm robots, a good strategy would be to construct a perfect mapping between input sensor data and appropriate control actions. The relation, however, is very complicated and highly nonlinear. In the first place, different types of sensors have different measurement characteristics. It would be difficult to estimate the spatial parameters using onboard sensors in order to determine the configuration relationships between the mobile robot and its immediate surroundings. On the other hand, it is well recognized that artificial neural networks have impressive capacity for nonlinear mapping and pattern-recognition applications. In this paper useful heuristics are combined into a fuzzy neural network to achieve the desired pattern-recognition results.

CURRENT RESULTS

For overcome the swarm formation control limitation, in this paper simple control algorithm is designed based on Fuzzy-Kohonen Networks (FKNs), due to simple algorithm. Three fundamental robot competencies for the execution of the FKNs algorithm are proposed such as, (i) the robot's ability of localizing itself, following the to a specific goal; (ii) the ability of communicating to the whole swarm that will follow this direction to the goal; and (iii) the capacity of detecting the local minima and share to other swarm.

The formation control is designed that allow swarms robots to converge in environments containing several shapes obstacles. The design of simple controllers for formation control and decentralized coordination with FKNs algorithm is used to synthesize shapes and environmental patterns, instead of restricting our environment. To investigate the feasibility of the proposed FKNs algorithm, some experiments is conducted by using five small robots with three gas sensors in it. From the real experiments produce swarm robots have the ability to synthesize several obstacle pattern shapes in these environments, and explicit coordination allowed robots to successfully navigate and moving to the goal.

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