Guest Editorial

Preface

Preface The field of multi-agent dynamical systems or simply swarms is a relatively new field that has become popular in the recent years. Getting its inspiration from the swarms in nature, the field has witnessed many developments. Operational principles developed (or obtained) from studying (or observing) the behavior of swarms in nature may be useful in developing effective functional engineering swarms. However, there are still many issues to be uncovered and resolved before engineering swarms are efficiently employed in real applications. First of all, there is a need for development of functional algorithms for agent coordination and control including basic interactions, cooperative and non-cooperative behaviors, task assignments and resource allocations. Second, effective inter-agent and agent-human communication and networking tools and protocols as well as necessary human-machine interfaces are needed. Third, appropriate sensory and cognitive agent capabilities such as adaptation, learning, reasoning, decision making, and agreement/consensus on individual and group (distributed) levels are needed for autonomous operation. While there has been some work using centralized approaches, the more common approach to solving these problems (or related sub-problems) is using decentralized (distributed) algorithms. This special issue aims to have a collection of the latest state-of-the-art research of the filed that highlight various aspects of the research problems in the multi-agent dynamic systems literature.

Papers

In this special issue there are one invited and nine contributed high quality articles reflecting different aspects and approaches in the field. The editor invited paper **"Swarms in Biology and Engineering"** is by one of the leading researchers in cooperative coordination and control field - Prof. Kevin M. Passino from the Ohio State University. This introductory philosophical article provides a short overview of the basic research problems and issues in the field as well as points out to the connections between biological and engineering swarms. The first contributed paper of the issue **"A Review of Studies on Swarm Robotics"** is a thorough survey of the research on swarm robotics that classifies the existing studies on swarm robotics under five taxonomic categories. The article **"Aggregation, Foraging, and Formation Control of Swarms with Non-Holonomic Agents Using Potential Functions and Sliding Mode Techniques"** is a control theoretic approach for swarm coordination and control problems such as aggregation, foraging, and formation control, of agents with non-holonomic velocity constraints using potential functions and the nonlinear sliding mode control method. Localization using only limited local information in multi-agent dynamic systems is an important problem. The article **"Using Angle of Arrival (Bearing) Information for Localization in Robot Networks"** is another interesting study that uses concepts/results from graph theory (such as the concept of globally rigid graphs) for localization in stationary robot networks using bearing information. In order for group of robots to be able to be employed in realistic applications, there is a need for developing of efficient route planning algorithms that converge and can be applied real-time. The article **"A VRP-Based Route Planning for a Mobile Robot Group"** addresses this problem to develop non-intersecting paths for a mobile robot group to solve the traveling salesman problem, an NP-hard problem. The authors develop an algorithm that converges very fast to a suboptimal solution which displays strong potential for real time implementation. The article **"Aggregation in Swarm Robotic Systems: Evolution and Probabilistic Control"** is another contribution considering the aggregation

problem in swarm robotic systems. It focuses on the development and the performance of neural network based aggregation controllers tuned through evolutionary methods (such as genetic algorithms) and behavior based probabilistic aggregation controllers based on the clustering capabilities of the swarm robotic system. The article **"Modeling a Deposition Process in Collective Construction"** considers a simulation model and a Markov chain based mathematical model to describe the deposition process of a robotic swarm system that uses templates and feedback to facilitate collective construction. The authors also implement the procedure using a small robotic swarm. Evolution in nature is a scientific fact that has also inspired many engineering applications. The results presented in the article **"Swarm Robot Systems Based on the Evolution of Personality Traits"** stipulate that a game theoretic approach for swam modeling in a changing environment together with personality traits (representing different robot behaviors) which can evolve (or can be learned) in time may lead to achieving intelligent behavior. As was mentioned above, effective feasible communication tools and protocols are needed to be developed for improving the performance of multi-robot systems. The last two articles tackle this aspect of the problem. The article **"A Communication Module and TDMA Scheduling for a Swarm of Small Submarines"** discusses a low frequency radio based communication system (as opposed to acoustic communication) for a submarine system. The authors show the advantages of small communication range (compared to the size of the swarm). Moreover, a time division multiple access (TDMA) algorithm and corresponding simulation results are also presented. The article entitled **"Design and Implementation of an Ad-Hoc Routing Protocol for Mobile Robots"** describes a communication library called PERA for low capacity wireless ad-hoc networks and its implementation on mobile robots. In their study the authors consider a system in which the robots can send messages to other robots that are not within their communication range through other robots (which act as routers). They discuss different aspects of the development of their protocol including design, implementation, and testing. The article guides those interested in implementation specific issues making it an interesting contribution.

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