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Contents

Guest Editorial

Special Issue on
Multi-agent Systems: Modeling, Control, and Applications

This Special Issue on "Multi-agent Systems: Modeling, Control, and Applications" in the International Journal of Information & Systems Sciences aims to present some most recent research developments and contributions in the field.

A multi-agent system is a group of interacting intelligent agents, in which the behavior of each individual is regulated based on its own dynamics and the information obtained from its neighboring agents. The overall topological structure of a multi-agent system is therefore composed of individual agent dynamics and information flows over the network composing of all these agents. Multi-agent systems provide a broad modeling framework which has been applied to diverse application areas, such as swarm intelligence [18], [25], group decision making [3], e-fashion [16], autonomous vehicles coordination [28], mobile robots gaming [9], [10], Internet distributed computing, sensors networking [27], [22], networked embedded systems [11], social economics [21], and agent-based crystallization [2], to name just some typical examples.

Intensive and extensive research has been carried out in all these research areas under the multi-agent systems framework. Consider swarm intelligence, for instance. A natural swarm can be a flock of birds, a school of fish, or a colony of ants; while an artificial swarm can be a group of robots. A central topic in swarm intelligence is the study of how collective swarm behaviors can emerge on a global scale when each individual has only a restricted view of the whole system and the interactions occur merely in a local scale [18]. An important model for swarm intelligence is the Vicsek model [29]. This simple discrete-time multi-agent system model demonstrates that directional consensus could be reached when each agent with a common constant velocity follows the average direction of its neighbors. This Vicsek model is by nature a special version of the Boid model, which embodies three fundamental roles: 1) collision avoidance, 2) velocity matching, and 3) flock centering [24]. Due to their simplicity and universality, the Vicsek model and its variants are recently being studied and applied in the physics as well as control and dynamical systems communities. Many important theoretical results have been obtained, e.g., the theoretic analysis on the Vicsek model [8], proposal of the first-order integrator model with switching topology and time delays [26], a non-balanced weighted directed graph structure [23], a convexity approach to consensus of nonlinear swarming models [19], non-smooth analysis approach to state agreement of continuous-time nonlinear swarming models [14], asynchronous consensus problem with time-varying delays and a switching topology [30], and some cited references therein.

Typical and central problems in modeling and control of multi-agent systems include: networked communications, networked dynamics, and decentralized control. Although multi-agent systems have attracted increasing attention and gained significant progress with some successful applications in various scientific and engineering areas in the past decade, numerous theoretical and technical challenges still remain, which must be satisfactorily addressed in order to build efficient multi-agent systems and associated control strategies for more and broader real-world applications.

In fact, the notion of multi-agent systems is classic. The subject has been studied under the frameworks of large-scale systems and systems complexity as well as decentralized control for years, yet mostly without taking their network connectivity topologies into consideration. The notion of complex dynamical networks, on the other hand, has recently seen dramatic increase of studies over almost all kinds of sciences and technologies, ranging from physical to biological, even to social sciences, and from wireless communications to Internet-based technologies alike. Their impacts on modern engineering and technology are prominent and will be far-reaching. Current research on complex networks of multi-agent dynamical systems, regarding their modeling, communication, stabilization, synchronization (or consensus) and control, as well as topological properties and dynamical features, has actually become overwhelming.

With a combined engineering and technological background from systems biology [6], [24], physics [29], computer science [20], as well as robotics [5], some modeling issues such as consensus [1], rendezvous [14], swarming [8], [29], flocking [24], network navigation [12], attractive-repulsive mechanism [4], [6], exogenous effects [7], [15] and, in particular, pinning control [13], [17], have all been under investigation. These problems have been effectively tackled by techniques from graph theory, control theory, stability analysis, stochastic processes, and algorithms design, among others. At the technical level, concerned issues include graph-theoretic properties, multi-agent dynamics, time-varying and time-delayed communication topologies, distributed computing and local feedback, etc., for hybrid multi-agent systems with continuous dynamics and discrete communications, altogether have posted various new challenges to research communities. Nevertheless, many significant research efforts and developments have been made, as reflected by many recent publications in different journals and conferences, as well as the feature articles in the present Special Issue.

In this Special Issue, we publish a collection of nine contributions, as detailed below.

In the first article, “Distributed control for consensus of networked multi-agent robotic systems with time delays”, an interesting case study is carried out by L. Sheng and Y. Pan, for the consensus operation of un-piloted combine harvesters in agriculture. The whole system is modeled as a multi-agent robotic vehicle system with a few significant dynamical and topological features. A very detailed numerical analysis is provided to validate the proposed methodology.

In the second article, “Coordination stabilization for multi-agent networks and control parametrization,” X. Wang studies the problem of stabilizing controller parametrization for multi-agent systems, which is applied to multi-agent systems with nonlinearities and time-varying uncertainties, where the approach taken is based on Lyapunov methods and linear differential inclusion.

In the third article, “Swarm intelligence over random networks,” F. Chen et al. study how to employ swarm intelligence to solve optimization problems more efficiently and effectively. The Erdos-Renyi random-network model is incorporated into the optimization algorithms, hoping that the swarm intelligence based on the network connectivity can in effect help to improve the intended optimization. The proposed network-based optimization is compared to the well-known genetic algorithms, demonstrating its great effectiveness.

In the fourth article, “Information control in a unified framework of consensus seeking,” H. Aguesse et al. introduces a new notion, generalized consensus, trying to unify consensus, chaotic map synchronization, formation reaching and path tracking. A case study is conducted for efficient synchronization of chaotic maps.

In the fifth article, “Formation control of multiple mobile robots via switching strategy,” J. Wu and Z. Jiang study the leader-follower formation control problem of multiple nonholonomic mobile robots, where the control objective is to keep the distance between robots and the angle of follower robots constant. A switching control law is designed to achieve this goal. A piece of software developed by the company MobileRobots is used in the numerical validation of the proposed control strategy.

In the sixth article, “Linguistic consensus on a circle,” by B. Wu et al., a particular consensus problem, linguistic consensus, is studied based on a weighted circle model. In this study, the central problem is under what condition all agents would eventually name an object with an identical signal chosen from a set of two elements. They prove that consensus can more likely be achieved when each agent has higher confidence in itself, therefore the parrot-like behavior might not be always helpful to reach a common state. Simulations support the proposed method and findings.

In the seventh article, “Recent advances in personal recommender systems,” J. Liu et al. review recent advances in personal recommender systems that can help users to find interested information from a large set of data, or from the Internet and the World Wide Web alike. Four commonly used tools were described and compared in terms of accuracy as well as efficiency, showing that hybrid recommendation algorithms may provide better services.

In the eighth article, “Modeling and decomposition of complex dynamic interconnected systems,” X. Ouyang and X. Chen study the topological structure and decomposition of complex dynamic interconnected systems, where complex dynamically interconnected systems are modeled as multi-overlapping dynamical systems with longitudinal structure, loop structure, or radial structure. A numerical example is presented for illustration.

Finally, in the ninth article, “Multi-agent resource conversion processes simulation,” K. Aksyonov et al. discuss a multi-agent dynamic resource conversion process for decision support systems and the implementation of BPsim.MAS, a SMES (simulation, modeling, expert system) tool. Augmented Petri networks and queueing systems are used as underlying mathematical models for such modeling.

We congratulate all the fine contributions to this Special Issue on “Multi-agent Systems: Modeling, Control, and Applications” of the International Journal of Information & Systems Sciences, and thank all the authors and reviewers for their time and efforts that altogether have finally made the publication of the issue a reality.

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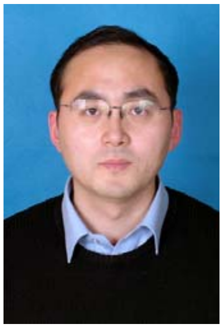

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