Cooperative Control Of Multi Agent Systems Optimal And Adaptive Design Approaches Communications And Control Engineering

This book investigates distributed cooperative control and communication of MASs including linear systems, nonlinear systems and multiple rigid body systems. The model-based and data-driven control method are employed to design the (optimal) cooperative control protocol. The approaches of this book consist of model-based and data-driven control such as predictive control, event-triggered control, optimal control, adaptive dynamic programming, etc. From this book, readers can learn about distributed cooperative control methods, data-driven control, finite-time stability analysis, cooperative attitude control of multiple rigid bodies. Some fundamental knowledge prepared to read this book is finite-time stability theory, event-triggered sampling mechanism, adaptive dynamic programming and optimal control.

This monograph is certainly for a specialist in multi-agent systems. It will be useful to researchers and to advanced course control engineers where multi-agent systems are covered. It's useful as a reference text and it has a good bibliography. Cooperative Control of Multi-Agent Systems offers a systematic framework for designing distributed controllers for multi-agent systems with general linear agent dynamics, linear agent dynamics with uncertainties, and Lipschitz nonlinear agent dynamics.The proposed consensus region decouples the design of the feedback gain matrices of the cooperative protocols from the communication graph and serves as a measure for the robustness of the protocols to variations of the communication graph.

This accessible book provides an introduction to the analysis and design of dynamic multiagent networks. Such networks are of great interest in a wide range of areas in science and engineering, including: mobile sensor networks, distributed robotics such as formation flying and swarming, quantum networks, networked economics, biological synchronization, and social networks. Focusing on graph theoretic methods for the analysis and synthesis of dynamic multiagent networks, the book presents a powerful new formalism and set of tools for networked systems. The book's three sections look at foundations, multiagent networks, and networks as systems. The authors give an overview of important ideas from graph theory, followed by a detailed account of the agreement protocol and its various extensions, including the behavior of the protocol over undirected, directed, switching, and random networks. They cover topics such as formation control, coverage, distributed estimation, social networks, and games over networks. And they explore intriguing aspects of viewing networks as systems, by making these networks amenable to control-theoretic analysis and automatic synthesis, by monitoring their dynamic evolution, and by examining higher-order interaction models in terms of simplicial complexes and their applications. The book will interest graduate students working in systems and control, as well as in computer science and robotics. It will be a standard reference for researchers seeking a self-contained account of system-theoretic aspects of multiagent networks and their wide-ranging applications. This book has been adopted as a textbook at the following universities: ? University of Stuttgart, Germany Royal Institute of Technology, Sweden Johannes Kepler University, Austria Georgia Tech, USA University of Washington, USA Ohio University, USA

Cooperative Control of Multi-agent Systems: An Optimal and Robust Perspective reports and encourages technology transfer in the field of cooperative control of multi-agent systems and presents recent advances in this area, contributed by leading international researchers in systems and control and specialists in engineering cybernetics. The book deals with new technological issues of cooperative control of multiple agents, such as UGVs, UAVs, UUVs, and spacecraft, etc. It presents an extended exposition of the authors' recent work in all aspects of multi-agent technology for a wide and rapid dissemination. Modelling and cooperative control of multi-agent systems are topics of great interest all over the world, across both academia (research and education) and industry (for real applications and and-users). Graduate students and researchers from a wide spectrum of specialties in electrical, mechanical, or aerospace engineering fields will use this book as a key resource. It will also be of keen interest to experts and industrial control engineers working to resolve cooperative control problems.

During the last decades, considerable progress has been observed in all aspects regarding the study of cooperative systems including modeling of cooperative systems, resource allocation, discrete event driven dynamical control, continuous and hybrid dynamical control, and theory of the interaction of information, control, and hierarchy. Solution methods have been proposed using control and optimization approaches, emergent rule based techniques, game theoretic and team theoretic approaches. Measures of performance have been suggested that include the effects of hierarchies and information structures on solutions, performance bounds, concepts of convergence and stability, and problem complexity. These and other topics were discusses at the Second Annual Conference on Cooperative Control and Optimization in Gainesville, Florida. Refereed papers written by selected conference participants from the conference are gathered in this volume, which presents problem models, theoretical results, and algorithms for various aspects of cooperative control. Audience: The book is addressed to faculty, graduate students, and researchers in optimization and control, computer sciences and engineering.

The paradigm of ‘multi-agent’ cooperative control is the challenge frontier for new control system application domains, and as a research area it has experienced a considerable increase in activity in recent years. This volume, the result of a UCLA collaborative project with Caltech, Cornell and MIT, presents cutting edge results in terms of the “dimensions” of cooperative control from leading researchers worldwide. This dimensional decomposition allows the reader to assess the multi-faceted landscape of cooperative control. Cooperative Control of Distributed Multi-Agent Systems is organized into four main themes, or dimensions, of cooperative control: distributed control and computation, adversarial interactions, uncertain evolution and complexity management. The military application of autonomous vehicles systems or multiple unmanned vehicles is primarily targeted; however much of the material is relevant to a broader range of multi-agent systems including cooperative robotics, distributed computing, sensor networks and data network congestion control. Cooperative Control of Distributed Multi-Agent Systems offers the reader an organized presentation of a variety of recent research advances, supporting software and experimental data on the resolution of the cooperative control problem. It will appeal to senior academics, researchers and graduate students as well as engineers working in the areas of cooperative systems, control and optimization.

This monograph presents new theories and methods for fixed-time cooperative control of multi-agent systems. Fundamental concepts of fixed-time stability and stabilization are introduced with insightful understanding. This book presents solutions for several problems of fixed-time cooperative control using systematic design methods. The book compares fixed-time cooperative control with asymptotic cooperative control, demonstrating how the former can achieve better closed-loop performance and disturbance rejection properties. It also discusses the differences from finite-time control, and shows how fixed-time cooperative control can produce the faster rate of convergence and provide an explicit estimate of the settling time independent of initial conditions. This monograph presents multiple applications of fixed-time control schemes, including to distributed optimization of multi-agent systems, making it useful to students, researchers and engineers alike.

The thesis presents new results on multi-agent formation control, focusing on the distributed stabilization control of rigid formation shapes. It analyzes a range of current research problems such as problems concerning the equilibrium and stability of formation control systems, or the problem of cooperative coordination control when agents have general dynamical models, and discusses practical considerations arising during the implementation of established formation control algorithms. In addition, the thesis presents models of increasing complexity, from single integrator models, to double integrator models, to agents modeled by nonlinear kinematic and dynamic equations, including the familiar unicycle model and nonlinear system equations with drift terms. Presenting the fruits of a close collaboration between several top control groups at leading universities including Yale University, Groningen University, Purdue University and Gwangju Institute of Science and Technology (GIST), the thesis spans various research areas, including robustness issues in formations, quantization-based coordination, exponential stability in formation systems, and cooperative coordination of networked heterogeneous systems.

This book presents a concise introduction to the latest advances in robust cooperative control design for multi-agent systems with input delay and external disturbances, especially from a prediction and observation perspective. The volume covers a wide range of applications, such as the trajectory tracking of quadrotors, formation flying of multiple unmanned aerial vehicles (UAVs) and fixed-time formation of ground vehicles. Robust cooperative control means that multi-agent systems are able to achieve specified control tasks while remaining robust in the face of both parametric and nonparametric model uncertainties. In addition, the authors cover a wide range of key issues in cooperative control, such as communication and input delays, parametric model uncertainties and external disturbances. Moving beyond the scope of existing works, a systematic prediction and observation approach to designing robust cooperative control laws is presented. About the Authors Chunyan Wang is an Associate Professor in the School of Aerospace Engineering at Beijing Institute of Technology, China. Zongyu Zuo is a full Professor with the School of Automation Science and Electrical Engineering, Beihang University, China. Jianan Wang is an Associate Professor in the School of Aerospace Engineering at Beijing Institute of Technology, China. Zhengtao Ding is a Professor in the Department of Electrical and Electronic Engineering at University of Manchester, U.K.

Assuming only neighbor-neighbor interaction among vehicles, this monograph develops distributed consensus strategies that ensure that the information states of all vehicles in a network converge to a common value. Readers learn to deal with groups of autonomous vehicles in aerial, terrestrial, and submarine environments. Plus, they get the tools needed to overcome impaired communication by using constantly updated neighbor-neighbor interchange.

Cooperative Control of Multi-Agent Systems: An Optimal and Robust Perspective reports and encourages technology transfer in the field of cooperative control of multi-agent systems. The book deals with UGVs, UAVs, UUVs and spacecraft, and more. It presents an extended exposition of the authors' recent work on all aspects of multi-agent technology. Modelling and cooperative control of multi-agent systems are topics of great interest, across both academia (research and education) and industry (for real applications and end-users). Graduate students and researchers from a wide spectrum of specialties in electrical, mechanical or aerospace engineering fields will use this book as a key resource. Helps shape the reader's understanding of optimal and robust cooperative control design techniques for multi-agent systems Presents new theoretical control challenges and investigates unresolved/open problems Explores future research trends in multi-agent systems Offers a certain amount of analytical mathematics, practical numerical procedures, and actual implementations of some proposed approaches

This volume surveys three decades of modern robot control theory and describes how the work of Suguru Arimoto shaped its development. Twelve survey articles written by experts associated with Suguru Arimoto at various stages in his career treat the subject comprehensively. This book provides an important reference for graduate students and researchers, as well as for mathematicians, engineers and scientists whose work involves robot control theory.

Are there universal principles of coordinated group motion and if so what might they be? This carefully edited book presents how natural groupings such as fish schools, bird flocks, deer herds etc. coordinate themselves and move so flawlessly, often without an apparent leader or any form of centralized control. It shows how the underlying principles of cooperative control may be used for groups of mobile autonomous agents to help enable a large group of autonomous robotic vehicles in the air, on land or sea or underwater, to collectively accomplish useful tasks such as distributed, adaptive scientific data gathering, search and rescue, or reconnaissance.

Far from being separate entities, many social and engineering systems can be considered as complex network systems (CNSs) associated with closely linked interactions with neighbouring entities such as the Internet and power grids. Roughly speaking, a CNS refers to a networking system consisting of lots of interactional individuals, exhibiting fascinating collective behaviour that cannot always be anticipated from the inherent properties of the individuals themselves. As one of the most fundamental examples of cooperative behaviour, consensus within CNSs (or the synchronization of complex networks) has gained considerable attention from various fields of research, including systems science, control theory and electrical engineering. This book mainly studies consensus of CNSs with dynamics topologies - unlike most existing books that have focused on consensus control and analysis for CNSs under a fixed topology. As most practical networks have limited communication ability, switching graphs can be used to characterize real-world communication topologies, leading to a wider range of practical applications. This book provides some novel multiple Lyapunov functions (MLFs), good candidates for analysing the consensus of CNSs with directed switching topologies, while each chapter provides detailed theoretical analyses according to the stability theory of switched systems. Moreover, numerical simulations are provided to validate the theoretical results. Both professional researchers and laypeople will benefit from this book.

Cooperative Control of Multi-Agent Systems provides a novel approach to designing distributed cooperative protocols for multi-agent systems with complex dynamics. The proposed consensus region decouples the design of the feedback gain matrices of the cooperative protocols from the communication graph and serves as a measure for the robustness of the protocols to variations of the communication graph. By exploiting the decoupling feature, adaptive cooperative protocols are presented that can be designed and implemented in a fully distributed fashion.

As intelligent autonomous agents and multiagent system applications become more pervasive, it becomes increasingly important to understand the risks associated with using these systems. Incorrect or inappropriate agent behavior can have harmful - fects, including financial cost, loss of data, and injury to humans or systems. For - ample, NASA has proposed missions where multiagent systems, working in space or on other planets, will need to do their own reasoning about safety issues that concern not only themselves but also that of their mission. Likewise, industry is interested in agent systems that can search for new supply opportunities and engage in (semi-) automated negotiations over new supply contracts. These systems should be able to securely negotiate such arrangements and decide which credentials can be requested and which credentials may be disclosed. Such systems may encounter environments that are only partially understood and where they must learn for themselves which aspects of their environment are safe and which are dangerous. Thus, security and safety are two central issues when developing and deploying such systems. We refer to a multiagent system's security as the ability of the system to deal with threats that are intentionally caused by other intelligent agents and/or s- tems, and the system's safety as its ability to deal with any other threats to its goals.

Cooperative Control Design: A Systematic, Passivity-Based Approach discusses multi-agent coordination problems, including formation control, attitude coordination, and synchronization. The goal of the book is to introduce passivity as a design tool for multi-agent systems, to provide exemplary work using this tool, and to illustrate its advantages in designing robust cooperative control algorithms. The discussion begins with an introduction to passivity and demonstrates how passivity can be used as a design tool for motion coordination. Followed by the case of adaptive redesigns for reference velocity recovery while describing a basic design, a modified design and the parameter convergence problem. Formation control is presented as it relates to relative distance control and relative position control. The coverage is concluded with a comprehensive discussion of agreement and the synchronization problem with an example using attitude coordination.

Distributed Coordination of Multi-agent Networks introduces problems, models, and issues such as collective periodic motion coordination, collective tracking with a dynamic leader, and containment control with multiple leaders, and explores ideas for their solution. Solving these problems extends the existing application domains of multi-agent networks; for example, collective periodic motion coordination is appropriate for applications involving repetitive movements, collective tracking guarantees tracking of a dynamic leader by multiple followers in the presence of reduced interaction and partial measurements, and containment control enables maneuvering of multiple followers by multiple leaders.

Time-Critical Cooperative Control of Autonomous Air Vehicles presents, in an easy-to-read style, the latest research conducted in the industry, while also introducing a set of novel ideas that illuminate a new approach to problem-solving. The book is virtually self-contained, giving the reader a complete, integrated presentation of the different concepts, mathematical tools, and control solutions needed to tackle and solve a number of problems concerning time-critical cooperative control of UAVs. By including case studies of fixed-wing and multirotor UAVs, the book effectively broadens the scope of application of the methodologies developed. This theoretical presentation is complemented with the results of flight tests with real UAVs, and is an ideal reference for researchers and practitioners from academia, research labs, commercial companies, government workers, and those in the international aerospace industry. Addresses important topics related to time-critical cooperative control of UAVs Describes solutions to the problems rooted in solid dynamical systems theory Applies the solutions developed to fixed-wing and multirotor UAVs Includes the results of field tests with both classes of UAVs

Multi-Agent Systems (MAS) use networked multiple autonomous agents to accomplish complex tasks in areas such as space-based applications, smart grids, and machine learning. The overall system goal is achieved using local interactions among the agents. The last two decades have witnessed rapid development of MASs in automatic control. Tracing the roots of such systems back more than 50 years, this monograph provides the reader with an in-depth and comprehensive survey of the research in Multi-Agent Systems. The focus is on the research conducted in the two decades. It introduces the basic concepts and definitions to the reader before going on to describe how MAS has been used in most forms of systems. The monograph offers a concise reference for understanding the use of MASs and the contemporary research issues for further investigation. In addition to covering the basic theory, the authors also cover applications in multi-robot systems, sensor networks, smart grid, machine learning, social networks, and many-core microprocessors. On the Control of Multi-Agent Systems provides researchers and students in systems and control a modern, comprehensive survey of one of the most important current day topics.

Cooperative Control of Multi-Agent Systems extends optimal control and adaptive control design methods to multi-agent systems on communication graphs. It develops Riccati design techniques for general linear dynamics for cooperative state feedback design, cooperative observer design, and cooperative dynamic output feedback design. Both continuous-time and discrete-time dynamical multi-agent systems are treated. Optimal cooperative control is introduced and neural adaptive design techniques for multi-agent nonlinear systems with unknown dynamics, which are rarely treated in literature are developed. Results spanning systems with first-, second- and on up to general high-order nonlinear dynamics are presented. Each control methodology proposed is developed by rigorous proofs. All algorithms are justified by simulation examples. The text is self-contained and will serve as an excellent comprehensive source of information for researchers and graduate students working with multi-agent systems.

A detailed and systematic introduction to the distributed cooperative control of multi-agent systems from a theoretical, network perspective Features detailed analysis and discussions on the distributed cooperative control and dynamics of multi-agent systems Covers comprehensively first order, second order and higher order systems, swarming and flocking behaviors Provides a broad theoretical framework for understanding the fundamentals of distributed cooperative control

Multiagent systems (MAS) are one of the most exciting and the fastest growing domains in the intelligent resource management and agent-oriented technology, which deals with modeling of autonomous decisions making entities. Recent developments have produced very encouraging results in the novel approach of handling multiplayer interactive systems. In particular, the multiagent system approach is adapted to model, control, manage or test the operations and management of several system applications including multi-vehicles, microgrids, multi-robots, where agents represent individual entities in the network. Each participant is modeled as an autonomous participant with independent strategies and responses to outcomes. They are able to operate autonomously and interact pro-actively with their environment. In recent works, the problem of information consensus is addressed, where a team of vehicles communicate with each other to agree on key pieces of information that enable them to work together in a coordinated fashion. The problem is challenging because communication channels have limited range and there are possibilities of fading and dropout. The book comprises chapters on synchronization and consensus in multiagent systems. It shows that the joint presentation of synchronization and consensus enables readers to learn about similarities and differences of both concepts. It reviews the cooperative control of multi-agent dynamical systems interconnected by a communication network topology. Using the terminology of cooperative control, each system is endowed with its own state variable and dynamics. A fundamental problem in multi-agent dynamical systems on networks is the design of distributed protocols that guarantee consensus or synchronization in the sense that the states of all the systems reach the same value. It is evident from the results that research in multiagent systems offer opportunities for further developments in theoretical, simulation and implementations. This book attempts to fill this gap and aims at presenting a comprehensive volume that documents theoretical aspects and practical applications.

Many of the problems and solutions considered involve combinations of both types of vehicles. Topics explored include target assignment, target tracking, consensus, stochastic game theory-based framework, event-triggered control, topology design and identification, coordination under uncertainty and coverage control.The superiority of multi-agent systems over single agents for the control of unmanned air, water and ground vehicles has been clearly demonstrated in a wide range of application areas. Their large-scale spatial distribution, robustness, high scalability and low cost enable multi-agent systems to achieve tasks that could not successfully be performed by even the most sophisticated single agent systems.

A comprehensive review of the state of the art in the control of multi-agent systems theory and applications The superiority of multi-agent systems over single agents for the control of unmanned air, water and ground vehicles has been clearly demonstrated in a wide range of application areas. Their large-scale spatial distribution, robustness, high scalability and low cost enable multi-agent systems to achieve tasks that could not successfully be performed by even the most sophisticated single agent systems. Cooperative Control of Multi-Agent Systems: Theory and Applications provides a wide-ranging review of the latest developments in the cooperative control of multi-agent systems theory and applications. The applications described are mainly in the areas of unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs). Throughout, the authors link basic theory to multi-agent cooperative control practice — illustrated within the context of highly-realistic scenarios of high-level missions — without losing site of the mathematical background needed to provide performance guarantees under general working conditions. Many of the problems and solutions considered involve combinations of both types of vehicles. Topics explored include target assignment, target tracking, consensus, stochastic game theory-based framework, event-triggered control, topology design and identification, coordination under uncertainty and coverage control. Establishes a bridge between fundamental cooperative control theory and specific problems of interest in a wide range of applications areas Includes example applications from the fields of space exploration, radiation shielding, site clearance, tracking/classification, surveillance, search-and-rescue and more Features detailed presentations of specific algorithms and application frameworks with relevant commercial and military applications Provides a comprehensive look at the latest developments in this rapidly evolving field, while offering informed speculation on future directions for collective control systems The use of multi-agent system technologies in both everyday commercial use and national defense is certain to increase tremendously in the years ahead, making this book a valuable resource for researchers, engineers, and applied mathematicians working in systems and controls, as well as advanced undergraduates and graduate students interested in those areas.

This book focuses on the characteristics of cooperative control problems for general linear multi-agent systems, including formation control, air traffic control, rendezvous, foraging, role assignment, and cooperative search. On this basis and combined with linear system theory, it introduces readers to the cooperative tracking problem for identical continuous-time multi-agent systems under state-coupled dynamics; the cooperative output regulation for heterogeneous multi-agent systems; and the optimal output regulation for model-free multi-agent systems. In closing, the results are extended to multiple leaders, and cooperative containment control for uncertain multi-agent systems is addressed. Given its scope, the book offers an essential reference guide for researchers and designers of multi-agent systems, as well as a valuable resource for upper-level undergraduate and graduate students.

This monograph introduces recent developments in formation control of distributed-agent systems. Eschewing the traditional concern with the dynamic characteristics of individual agents, the book proposes a treatment that studies the formation control problem in terms of interactions among agents including factors such as sensing topology, communication and actuation topologies, and computations. Keeping pace with recent technological advancements in control, communications, sensing and computation that have begun to bring the applications of distributed-systems theory out of the industrial sphere and into that of day-to-day life, this monograph provides distributed control algorithms for a group of agents that may behave together. Unlike traditional control laws that usually require measurements with respect to a global coordinate frame and communications between a centralized operation center and agents, this book provides control laws that require only relative measurements and communications between agents without interaction with a centralized operator. Since the control algorithms presented in this book do not require any global sensing and any information exchanges with a centralized operation center, they can be realized in a fully distributed way, which significantly reduces the operation and implementation costs of a group of agents. Formation Control will give both students and researchers interested in pursuing this field a good grounding on which to base their work.

Distributed controller design is generally a challenging task, especially for multi-agent systems with complex dynamics, due to the interconnected effect of the agent dynamics, the interaction graph among agents, and the cooperative control laws. Cooperative Control of Multi-Agent Systems: A Consensus Region Approach offers a systematic framework for designing distributed controllers for multi-agent systems with general linear agent dynamics, linear agent dynamics with uncertainties, and Lipschitz nonlinear agent dynamics. Beginning with an introduction to cooperative control and graph theory, this monograph: Explores the consensus control problem for continuous-time and discrete-time linear multi-agent systems Studies the H? and H2 consensus problems for linear multi-agent systems subject to external disturbances Designs distributed adaptive consensus protocols for continuous-time linear multi-agent systems Considers the distributed tracking control problem for linear multi-agent systems with a leader of nonzero control input Examines the distributed containment control problem for the case with multiple leaders Covers the robust cooperative control problem for multi-agent systems with linear nominal agent dynamics subject to heterogeneous matching uncertainties Discusses the global consensus problem for Lipschitz nonlinear multi-agent systems Cooperative Control of Multi-Agent Systems: A Consensus Region Approach provides a novel approach to designing distributed cooperative protocols for multi-agent systems with complex dynamics. The proposed consensus region decouples the design of the feedback gain matrices of the cooperative protocols from the communication graph and serves as a measure for the robustness of the protocols to variations of the communication graph. By exploiting the decoupling feature, adaptive cooperative protocols are presented that can be designed and implemented in a fully distributed fashion.

Networked Control Systems (NCSs) are spatially distributed systems for which the communication between sensors, actuators and controllers is realized by a shared (wired or wireless) communication network. NCSs offer several advantages, such as reduced installation and maintenance costs, as well as greater flexibility, over conventional control systems in which parts of control loops exchange information via dedicated point-to-point connections. The principal goal of this book is to present a coherent and versatile framework applicable to various settings investigated by the authors over the last several years. This framework is applicable to nonlinear time-varying dynamic plants and controllers with delayed dynamics; a large class of static, dynamic, probabilistic and priority-oriented scheduling protocols; delayed, noisy, lossy and intermittent information exchange; decentralized control problems of heterogeneous agents with time-varying directed (not necessarily balanced) communication topologies; state- and output-feedback; off-line and on-line intermittent feedback; optimal intermittent feedback through Approximate Dynamic Programming (ADP) and Reinforcement Learning (RL); and control systems with exogenous disturbances and modeling uncertainties.

Providing a guided tour of the pioneering work and major technical issues, Multiagent Robotic Systems addresses learning and adaptation in decentralized autonomous robots. Its systematic examination demonstrates the interrelationships between the autonomy of individual robots and the emerged global behavior properties of a group performing a cooperative task. The author also includes descriptions of the essential building blocks of the architecture of autonomous mobile robots with respect to their requirement on local behavioral conditioning and group behavioral evolution. After reading this book you will be able to fully appreciate the strengths and usefulness of various approaches in the development and application of multiagent robotic systems. It covers: Why and how to develop and experimentally test the computational mechanisms for learning and evolving sensory-motor control behaviors in autonomous robots How to design and develop evolutionary algorithm-based group behavioral learning mechanisms for the optimal emergence of group behaviors How to enable group robots to converge to a finite number of desirable task states through group learning What are the effects of the local learning mechanisms on the emergent global behaviors How to use decentralized, self-organizing autonomous robots to perform cooperative tasks in an unknown environment Earlier works have focused primarily on how to navigate in a spatially unknown environment, given certain predefined motion behaviors. What is missing, however, is an in-depth look at the important issues on how to effectively obtain such behaviors in group robots and how to enable behavioral learning and adaptation at the group level. Multiagent Robotic Systems examines the key methodological issues and gives you an understanding of the underlying computational models and techniques for multiagent systems.

This book presents a systematic study of an emerging field in the development of multi-agent systems. In a wide spectrum of applications, it is now common to see that multiple agents work cooperatively to accomplish a complex task. The book assists the implementation of such applications by promoting the ability of multi-agent systems to track — using local communication only — the mean value of signals of interest, even when these change rapidly with time and when no individual agent has direct access to the average signal across the whole team; for example, when a better estimation/control performance of multi-robot systems has to be guaranteed, it is desirable for each robot to compute or track the averaged changing measurements of all the robots at any time by communicating with only local neighboring robots. The book covers three factors in successful distributed average tracking: algorithm design via nonsmooth and extended PI control; distributed average tracking for double-integrator, general-linear, Euler–Lagrange, and input-saturated dynamics; and applications in dynamic region-following formation control and distributed convex optimization. The book presents both the theory and applications in a general but self-contained manner, making it easy to follow for newcomers to the topic. The content presented fosters research advances in distributed average tracking and inspires future research directions in the field in academia and industry.

Cooperative Control of Multi-Agent SystemsOptimal and Adaptive Design ApproachesSpringer Science & Business Media

Stability theory has allowed us to study both qualitative and quantitative properties of dynamical systems, and control theory has played a key role in designing numerous systems. Contemporary sensing and communication n- works enable collection and subscription of geographically-distributed inf- mation and such information can be used to enhance signi?cantly the perf- manceofmanyofexisting systems. Throughasharedsensing/communication network,heterogeneoussystemscannowbecontrolledtooperaterobustlyand autonomously; cooperative control is to make the systems act as one group and exhibit certain cooperative behavior, and it must be pliable to physical and environmental constraints as well as be robust to intermittency, latency and changing patterns of the information ?ow in the network. This book attempts to provide a detailed coverage on the tools of and the results on analyzing and synthesizing cooperative systems. Dynamical systems under consideration can be either continuous-time or discrete-time, either linear or non-linear, and either unconstrained or constrained. Technical contents of the book are divided into three parts. The ?rst part consists of Chapters 1, 2, and 4. Chapter 1 provides an overview of coope- tive behaviors, kinematical and dynamical modeling approaches, and typical vehicle models. Chapter 2 contains a review of standard analysis and design tools in both linear control theory and non-linear control theory. Chapter 4 is a focused treatment of non-negativematrices and their properties,multipli- tive sequence convergence of non-negative and row-stochastic matrices, and the presence of these matrices and sequences in linear cooperative systems.

This book brings together emerging objectives and paradigms in the control of both AC and DC microgrids; further, it facilitates the integration of renewable-energy and distribution systems through localization of generation, storage and consumption. The control objectives in a microgrid are addressed through the hierarchical control structure. After providing a comprehensive survey on the state of the art in microgrid control, the book goes on to address the most recent control schemes for both AC and DC microgrids, which are based on the distributed cooperative control of multi-agent systems. The cooperative control structure discussed distributes the co-ordination and optimization tasks across all distributed generators. This does away with the need for a central controller, and the control system will not collapse in response to the outage of a single unit. This avoids adverse effects on system flexibility and configurability, as well as the reliability concerns in connection with single points of failure that arise in traditional, centralized microgrid control schemes. Rigorous proofs develop each control methodology covered in the book, and simulation examples are provided to justify all of the proposed algorithms. Given its extensive yet self-contained content, the book offers a comprehensive source of information for graduate students, academic researchers, and practicing engineers working in the field of microgrid control and optimization.