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Graph Theoretic Methods in Multiagent Networks

Mehran Mesbahi
and Magnus Egerstedt

Graph Theoretic Methods In Multiagent Networks Princeton Series In Applied Mathematics

Nikolaus Correll,Mac Schwager,Michael Otte

Graph Theoretic Methods In Multiagent Networks Princeton Series In Applied Mathematics:

Graph Theoretic Methods in Multiagent Networks Mehran Mesbahi,Magnus Egerstedt,2010-07-01 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

Distributed Optimization-Based Control of Multi-Agent Networks in Complex Environments Minghui Zhu,Sonia Martínez,2015-06-11 This book offers a concise and in depth exposition of specific algorithmic solutions for distributed optimization based control of multi agent networks and their performance analysis It synthesizes and analyzes distributed strategies for three collaborative tasks distributed cooperative optimization mobile sensor deployment and multi vehicle formation control The book integrates miscellaneous ideas and tools from dynamic systems control theory graph theory optimization game theory and Markov chains to address the particular challenges introduced by such complexities in the environment as topological dynamics environmental uncertainties and potential cyber attack by human adversaries The book is written for first or second year graduate students in a variety of engineering disciplines including control robotics decision making optimization and algorithms and with backgrounds in aerospace engineering computer science electrical engineering mechanical engineering and operations research Researchers in these areas may also find the book useful as a reference

Network Optimization Methods in Passivity-Based Cooperative Control Miel Sharf,2021-05-24 This book establishes an important mathematical connection between cooperative control problems and network optimization problems It shows that many cooperative control problems can in fact be understood under certain passivity assumptions using a pair of static

network optimization problems Merging notions from passivity theory and network optimization it describes a novel network optimization approach that can be applied to the synthesis of controllers for diffusively coupled networks of passive or passivity short dynamical systems It also introduces a data based model free approach for the synthesis of network controllers for multi agent systems with passivity short agents Further the book describes a method for monitoring link faults in multi agent systems using passivity theory and graph connectivity It reports on some practical case studies describing the effectivity of the developed approaches in vehicle networks All in all this book offers an extensive source of information and novel methods in the emerging field of multi agent cooperative control paving the way to future developments of autonomous systems for various application domains New Frontiers in Graph Theory Yagang Zhang,2012-03-02 Nowadays graph theory is an important analysis tool in mathematics and computer science Because of the inherent simplicity of graph theory it can be used to model many different physical and abstract systems such as transportation and communication networks models for business administration political science and psychology and so on The purpose of this book is not only to present the latest state and development tendencies of graph theory but to bring the reader far enough along the way to enable him to embark on the research problems of his own Taking into account the large amount of knowledge about graph theory and practice presented in the book it has two major parts theoretical researches and applications The book is also intended for both graduate and postgraduate students in fields such as mathematics computer science system sciences biology engineering cybernetics and social sciences and as a reference for software professionals and practitioners **Statistical Inference via Convex Optimization** Anatoli Juditsky,Arkadi Nemirovski,2020-04-07 This authoritative book draws on the latest research to explore the interplay of high dimensional statistics with optimization Through an accessible analysis of fundamental problems of hypothesis testing and signal recovery Anatoli Juditsky and Arkadi Nemirovski show how convex optimization theory can be used to devise and analyze near optimal statistical inferences Statistical Inference via Convex Optimization is an essential resource for optimization specialists who are new to statistics and its applications and for data scientists who want to improve their optimization methods Juditsky and Nemirovski provide the first systematic treatment of the statistical techniques that have arisen from advances in the theory of optimization They focus on four well known statistical problems sparse recovery hypothesis testing and recovery from indirect observations of both signals and functions of signals demonstrating how they can be solved more efficiently as convex optimization problems The emphasis throughout is on achieving the best possible statistical performance The construction of inference routines and the quantification of their statistical performance are given by efficient computation rather than by analytical derivation typical of more conventional statistical approaches In addition to being computation friendly the methods described in this book enable practitioners to handle numerous situations too difficult for closed analytical form analysis such as composite hypothesis testing and signal recovery in inverse problems Statistical Inference via Convex Optimization features exercises with solutions along with

extensive appendixes making it ideal for use as a graduate text *Introduction to Averaging Dynamics over Networks* Fabio Fagnani,Paolo Frasca,2017-11-09 This book deals with averaging dynamics a paradigmatic example of network based dynamics in multi agent systems The book presents all the fundamental results on linear averaging dynamics proposing a unified and updated viewpoint of many models and convergence results scattered in the literature Starting from the classical evolution of the powers of a fixed stochastic matrix the text then considers more general evolutions of products of a sequence of stochastic matrices either deterministic or randomized The theory needed for a full understanding of the models is constructed without assuming any knowledge of Markov chains or Perron Frobenius theory Jointly with their analysis of the convergence of averaging dynamics the authors derive the properties of stochastic matrices These properties are related to the topological structure of the associated graph which in the book s perspective represents the communication between agents Special attention is paid to how these properties scale as the network grows in size Finally the understanding of stochastic matrices is applied to the study of other problems in multi agent coordination averaging with stubborn agents and estimation from relative measurements The dynamics described in the book find application in the study of opinion dynamics in social networks of information fusion in sensor networks and of the collective motion of animal groups and teams of unmanned vehicles Introduction to Averaging Dynamics over Networks will be of material interest to researchers in systems and control studying coordinated or distributed control networked systems or multiagent systems and to graduate students pursuing courses in these areas **Graph Theoretic Methods in Multiagent Networks** Mehran Mesbahi,Magnus Egerstedt,2010-07-21 An introduction to the analysis design of dynamic multiagent networks These have a wide range of applications in science engineering including mobile sensor networks distributed robotics quantum networks networked economics biological synchronization social networks *Structures of Domination in Graphs* Teresa W. Haynes,Stephen T. Hedetniemi,Michael A. Henning,2021-05-04 This volume comprises 17 contributions that present advanced topics in graph domination featuring open problems modern techniques and recent results The book is divided into 3 parts The first part focuses on several domination related concepts broadcast domination alliances domatic numbers dominator colorings irredundance in graphs private neighbor concepts game domination varieties of Roman domination and spectral graph theory The second part covers domination in hypergraphs chessboards and digraphs and tournaments The third part focuses on the development of algorithms and complexity of signed minus and majority domination power domination and alliances in graphs The third part also includes a chapter on self stabilizing algorithms Of extra benefit to the reader the first chapter includes a glossary of commonly used terms The book is intended to provide a reference for established researchers in the fields of domination and graph theory and graduate students who wish to gain knowledge of the topics covered as well as an overview of the major accomplishments and proof techniques used in the field **Model Reduction of Complex Dynamical Systems** Peter Benner,Tobias Breiten,Heike Faßbender,Michael Hinze,Tatjana Stykel,Ralf

Zimmermann,2021-08-26 This contributed volume presents some of the latest research related to model order reduction of complex dynamical systems with a focus on time dependent problems Chapters are written by leading researchers and users of model order reduction techniques and are based on presentations given at the 2019 edition of the workshop series Model Reduction of Complex Dynamical Systems MODRED held at the University of Graz in Austria The topics considered can be divided into five categories system theoretic methods such as balanced truncation Hankel norm approximation and reduced basis methods data driven methods including Loewner matrix and pencil based approaches dynamic mode decomposition and kernel based methods surrogate modeling for design and optimization with special emphasis on control and data assimilation model reduction methods in applications such as control and network systems computational electromagnetics structural mechanics and fluid dynamics and model order reduction software packages and benchmarks This volume will be an ideal resource for graduate students and researchers in all areas of model reduction as well as those working in applied mathematics and theoretical informatics *Multi-UAV Planning and Task Allocation* Yasmina Bestaoui Sebbane,2020-03-27 Multi robot systems are a major research topic in robotics Designing testing and deploying aerial robots in the real world is a possibility due to recent technological advances This book explores different aspects of cooperation in multiagent systems It covers the team approach as well as deterministic decision making It also presents distributed receding horizon control as well as conflict resolution artificial potentials and symbolic planning The book also covers association with limited communications as well as genetic algorithms and game theory reasoning Multiagent decision making and algorithms for optimal planning are also covered along with case studies Key features Provides a comprehensive introduction to multi robot systems planning and task allocation Explores multi robot aerial planning flight planning orienteering and coverage and deployment patrolling and foraging Includes real world case studies Treats different aspects of cooperation in multiagent systems Both scientists and practitioners in the field of robotics will find this text valuable **Advanced Distributed Consensus for Multiagent Systems** Magdi S. Mahmoud,Mojeed O. Oyedeji,Yuanqing Xia,2020-12-05 Advanced Distributed Consensus for Multiagent Systems contributes to the further development of advanced distributed consensus methods for different classes of multiagent methods The book expands the field of coordinated multiagent dynamic systems including discussions on swarms multi vehicle and swarm robotics In addition it addresses advanced distributed methods for the important topic of multiagent systems with a goal of providing a high level treatment of consensus to different versions while preserving systematic analysis of the material and providing an accounting to math development in a unified way This book is suitable for graduate courses in electrical mechanical and computer science departments Consensus control in multiagent systems is becoming increasingly popular among researchers due to its applicability in analyzing and designing coordination behaviors among agents in multiagent frameworks Multiagent systems have been a fascinating subject amongst researchers as their practical applications span multiple fields ranging from robotics control theory systems biology evolutionary biology

power systems social and political systems to mention a few Gathers together the theoretical preliminaries and fundamental issues related to multiagent systems and controls Provides coherent results on adopting a multiagent framework for critically examining problems in smart microgrid systems Presents advanced analysis of multiagent systems under cyberphysical attacks and develops resilient control strategies to guarantee safe operation *Mathematical Control Theory I* M. Kanat Camlibel,A. Agung Julius,Ramkrishna Pasumarthy,Jacquelien M.A. Scherpen,2015-07-15 This treatment of modern topics related to mathematical systems theory forms the proceedings of a workshop Mathematical Systems Theory From Behaviors to Nonlinear Control held at the University of Groningen in July 2015 The workshop celebrated the work of Professors Arjan van der Schaft and Harry Trentelman honouring their 60th Birthdays The first volume of this two volume work covers a variety of topics related to nonlinear and hybrid control systems After giving a detailed account of the state of the art in the related topic each chapter presents new results and discusses new directions As such this volume provides a broad picture of the theory of nonlinear and hybrid control systems for scientists and engineers with an interest in the interdisciplinary field of systems and control theory The reader will benefit from the expert participants ideas on exciting new approaches to control and system theory and their predictions of future directions for the subject that were discussed at the workshop

PDE Control of String-Actuated Motion Ji Wang,Miroslav Krstic,2022-10-25 New adaptive and event triggered control designs with concrete applications in undersea construction offshore drilling and cable elevators Control applications in undersea construction cable elevators and offshore drilling present major methodological challenges because they involve PDE systems cables and drillstrings of time varying length coupled with ODE systems the attached loads or tools that usually have unknown parameters and unmeasured states In PDE Control of String Actuated Motion Ji Wang and Miroslav Krstic develop control algorithms for these complex PDE ODE systems evolving on time varying domains Motivated by physical systems the book s algorithms are designed to operate with rigorous mathematical guarantees in the presence of real world challenges such as unknown parameters unmeasured distributed states environmental disturbances delays and event triggered implementations The book leverages the power of the PDE backstepping approach and expands its scope in many directions Filled with theoretical innovations and comprehensive in its coverage PDE Control of String Actuated Motion provides new design tools and mathematical techniques with far reaching potential in adaptive control delay systems and event triggered control A Dynamical Systems Theory of Thermodynamics Wassim M. Haddad,2019-06-04 A brand new conceptual look at dynamical thermodynamics This book merges the two universalisms of thermodynamics and dynamical systems theory in a single compendium with the latter providing an ideal language for the former to develop a new and unique framework for dynamical thermodynamics In particular the book uses system theoretic ideas to bring coherence clarity and precision to an important and poorly understood classical area of science The dynamical systems formalism captures all of the key aspects of thermodynamics including its fundamental laws while providing a mathematically rigorous

formulation for thermodynamical systems out of equilibrium by unifying the theory of mechanics with that of classical thermodynamics This book includes topics on nonequilibrium irreversible thermodynamics Boltzmann thermodynamics mass action kinetics and chemical reactions finite time thermodynamics thermodynamic critical phenomena with continuous and discontinuous phase transitions information theory continuum and stochastic thermodynamics and relativistic thermodynamics A Dynamical Systems Theory of Thermodynamics develops a postmodern theory of thermodynamics as part of mathematical dynamical systems theory The book establishes a clear nexus between thermodynamic irreversibility the second law of thermodynamics and the arrow of time to further unify discreteness and continuity indeterminism and determinism and quantum mechanics and general relativity in the pursuit of understanding the most fundamental property of the universe the entropic arrow of time **Achieving Consensus in Robot Swarms** Gabriele Valentini,2017-02-14 This book focuses on the design and analysis of collective decision making strategies for the best of n problem After providing a formalization of the structure of the best of n problem supported by a comprehensive survey of the swarm robotics literature it introduces the functioning of a collective decision making strategy and identifies a set of mechanisms that are essential for a strategy to solve the best of n problem The best of n problem is an abstraction that captures the frequent requirement of a robot swarm to choose one option from of a finite set when optimizing benefits and costs The book leverages the identification of these mechanisms to develop a modular and model driven methodology to design collective decision making strategies and to analyze their performance at different level of abstractions Lastly the author provides a series of case studies in which the proposed methodology is used to design different strategies using robot experiments to show how the designed strategies can be ported to different application scenarios Distributed Autonomous Robotic Systems Nikolaus Correll,Mac Schwager,Michael Otte,2019-01-29 This volume of the SPAR series brings the proceedings of the fourteen edition of the DARS symposium on Distributed Autonomous Robotic Systems whose proceedings have been published within SPAR since the past edition This symposium took place in Boulder CO from October 15th to 17th 2018 The volume edited by Nikolaus Correll and Mac Schwager contains 36 scientific contributions cutting across planning control design perception networking and optimization all united through the common thread of distributed robotic systems Optimization and Learning via Stochastic Gradient Search Felisa Vázquez-Abad,Bernd Heidergott,2025-10-14 An introduction to gradient based stochastic optimization that integrates theory and implementation This book explains gradient based stochastic optimization exploiting the methodologies of stochastic approximation and gradient estimation Although the approach is theoretical the book emphasizes developing algorithms that implement the methods The underlying philosophy of this book is that when solving real problems mathematical theory the art of modeling and numerical algorithms complement each other with no one outlook dominating the others The book first covers the theory of stochastic approximation including advanced models and state of the art analysis methodology treating applications that do not require the use of gradient estimation It

then presents gradient estimation developing a modern approach that incorporates cutting edge numerical algorithms Finally the book culminates in a rich set of case studies that integrate the concepts previously discussed into fully worked models The use of stochastic approximation in statistics and machine learning is discussed and in depth theoretical treatments for selected gradient estimation approaches are included Numerous examples show how the methods are applied concretely and end of chapter exercises enable readers to consolidate their knowledge Many chapters end with a section on Practical Considerations that addresses typical tradeoffs encountered in implementation The book provides the first unified treatment of the topic written for a wide audience that includes researchers and graduate students in applied mathematics engineering computer science physics and economics **Delay-Adaptive Linear Control** Yang Zhu,Miroslav Krstic,2020-04-28 Actuator and sensor delays are among the most common dynamic phenomena in engineering practice and when disregarded they render controlled systems unstable Over the past sixty years predictor feedback has been a key tool for compensating such delays but conventional predictor feedback algorithms assume that the delays and other parameters of a given system are known When incorrect parameter values are used in the predictor the resulting controller may be as destabilizing as without the delay compensation Delay Adaptive Linear Control develops adaptive predictor feedback algorithms equipped with online estimators of unknown delays and other parameters Such estimators are designed as nonlinear differential equations which dynamically adjust the parameters of the predictor The design and analysis of the adaptive predictors involves a Lyapunov stability study of systems whose dimension is infinite because of the delays and nonlinear because of the parameter estimators This comprehensive book solves adaptive delay compensation problems for systems with single and multiple inputs outputs unknown and distinct delays in different input channels unknown delay kernels unknown plant parameters unmeasurable finite dimensional plant states and unmeasurable infinite dimensional actuator states Presenting breakthroughs in adaptive control and control of delay systems Delay Adaptive Linear Control offers powerful new tools for the control engineer and the mathematician Mathematical Methods in Elasticity Imaging Habib Ammari,Elie Bretin,Josselin Garnier,Hyeonbae Kang,Hyundae Lee,Abdul Wahab,2015-04-06 This book is the first to comprehensively explore elasticity imaging and examines recent important developments in asymptotic imaging modeling and analysis of deterministic and stochastic elastic wave propagation phenomena It derives the best possible functional images for small inclusions and cracks within the context of stability and resolution and introduces a topological derivative based imaging framework for detecting elastic inclusions in the time harmonic regime For imaging extended elastic inclusions accurate optimal control methodologies are designed and the effects of uncertainties of the geometric or physical parameters on stability and resolution properties are evaluated In particular the book shows how localized damage to a mechanical structure affects its dynamic characteristics and how measured eigenparameters are linked to elastic inclusion or crack location orientation and size Demonstrating a novel method for identifying locating and estimating inclusions and cracks in

elastic structures the book opens possibilities for a mathematical and numerical framework for elasticity imaging of nanoparticles and cellular structures **The Role of Population Games in the Design of Optimization-Based Controllers** Julian Barreiro-Gomez,2018-08-01 This book reports on the implementation of evolutionary game theory in the design of distributed optimization based controllers First it discusses how the classical population game approach can contribute to and complement the design of optimization based controllers It shows how the features of this approach can be exploited to extend their capabilities in the solution of distributed optimization problems and examines density games in order to consider multiple coupled constraints and preserve the non centralized information requirements Furthermore it establishes a close relationship between the possible interactions among agents in a population with constrained information sharing among different local controllers It also discusses coalitional games focusing on the Shapley power index and proposes an alternative method of computing the latter which reduces computational time as well as a different way of finding it using distributed communication structures All the proposed strategies are then tested on various control problems such as those related to the Barcelona water supply network multiple continuous stirred tank reactors various unmanned aerial vehicle systems and a water distribution system This thesis examined at the Universitat Polit cnica de Catalunya and Universidad de los Andes in 2017 received the award for best thesis in control from the control group of the Spanish Committee of Automatic Control CEA in the same year

Graph Theoretic Methods In Multiagent Networks Princeton Series In Applied Mathematics Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has be more apparent than ever. Its ability to stir emotions, provoke thought, and instigate transformation is actually remarkable. This extraordinary book, aptly titled "**Graph Theoretic Methods In Multiagent Networks Princeton Series In Applied Mathematics**," compiled by a very acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound effect on our existence. Throughout this critique, we shall delve into the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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