Distributed Control Of Robotic Networks A Mathematical Approach To Motion Coordination Algorithms Princeton Series In Applied Mathematics

Developments in bio-inspired computation have impacted multiple fields and created opportunities for new applications. In recent years, these techniques have been increasingly integrated into robotic systems. Membrane Computing for Distributed Control of Robotic Swarms: Emerging Research and Opportunities is an innovative reference source for the latest perspectives on biologically-inspired computation techniques for robot design and control. Highlighting a range of pivotal topics such as software engineering, simulation tools, and robotic security, this book is ideally designed for researchers, academics, students, and practitioners interested in the role of membrane computing in mobile robots.
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Selected contributions to the Workshop WAFR 2002, held December 15-17, 2002, Nice, France. This fifth biannual Workshop on Algorithmic Foundations of Robotics focuses on algorithmic issues related to robotics and automation. The

design and analysis of robot algorithms raises fundamental questions in computer science, computational geometry, mechanical modeling, operations research, control theory, and associated fields. The highly selective program highlights significant new results such as algorithmic models and complexity bounds. The validation of algorithms, design concepts, or techniques is the common thread running through this focused collection.

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. Distributed robotics is an interdisciplinary and rapidly growing area, combining research in computer science, communication and control systems, and electrical and mechanical engineering. Distributed robotic systems can autonomously solve complex problems while operating in highly unstructured real-world environments. They are expected to play a major role in addressing future societal needs, for example, by improving environmental impact assessment, food supply, transportation, manufacturing, security, and emergency and rescue services. The goal of the International Symposium on Distributed Autonomous Robotic Systems (DARS) is to provide a forum for scientific advances in the theory and practice of distributed autonomous robotic systems. This volume of proceedings include 47 original contributions presented at the 13th International Symposium on Distributed Autonomous Robotic Systems (DARS 2016), which was held at the Natural History Museum in London, UK, from November 7th to 9th, 2016. The selected papers in this volume are authored by leading researchers from around the world, thereby providing a broad coverage and perspective of the state-of-the-art technologies, algorithms, system architectures, and applications in distributed robotic systems. The book is organized into seven parts, representative of critical long-term and emerging research thrusts in the multi-robot community: Distributed Coverage and Exploration; Multi-Robot Control; Multi-Robot Estimation; Multi-Robot Planning; Modular Robots and Smart Materials; Swarm Robotics; and Multi-Robot Systems in Applications. Microprocessors play a dominant role in computer technology and have contributed uniquely in the development of many new concepts and design techniques for modem industrial systems. This contribution is excessively high in the area of robotic and manufacturing systems. However, it is the editor's feeling that a reference book describing this contribution in a cohesive way and covering the major hardware and software issues is lacking. The purpose of this book is exactly to fill in this gap through the collection and presentation of the experience of a number of experts and professionals working in different academic and industrial environments. The book is divided in three parts. Part 1 involves the first four chapters and deals with the utilization of microprocessors and digital signal processors (DSPs) for the computation of robot dynamics. The emphasis here is on parallel computation with particular problems attacked being task granularity, task allocation/scheduling and communication issues. Chapter I, by Zheng and Hemami, is concerned with the real-time multiprocessor computation of torques in robot control systems via the Newton-Euler equations. This reduces substantially the height of the evaluation tree which leads to more effective parallel processing. Chapter 2, by D'Hollander, examines thoroughly the automatic scheduling of the Newton-Euler inverse dynamic equations. The automatic program decomposition and scheduling techniques developed are embedded in a tool used to generate multiprocessor schedules from a high-level language program.

The 6th International Symposium on Distributed Autonomous Robotic Systems (DARS 2002) was held in June 2002 in Fukuoka, Japan, a decade after the first DARS symposium was convened. This book, containing the proceedings of the symposium, provides broad coverage of the technical issues in the current state of the art in distributed autonomous systems composed of multiple robots, robotic modules, or robotic agents. DARS 2002 dealt with new strategies for realizing complex, modular, robust, and fault-tolerant robotic systems, and this volume covers the technical areas of system design, modeling, simulation, operation, sensing, planning, and control. The papers that are included here were contributed by leading researchers from Asia, Oceania, Europe, and the Americas, and make up an invaluable resource for researchers and students in the field of distributed autonomous robotic systems.

A comprehensive survey of the growing field of self-reconfigurable robots that discusses the history of the field, design considerations, and control strategies. Self-reconfigurable robots are constructed of robotic modules that can be connected in many different ways. These modules move in relationship to each other, which allows the robot as a whole to change shape. This shapeshifting makes it possible for the robots to adapt and optimize their shapes for different tasks. Thus, a self-reconfigurable robot can first assume the shape of a rolling track to cover distance quickly, then the shape of a snake to explore a narrow space, and finally the shape of a hexapod to carry an artifact back to the starting point. The field of self-reconfigurable robots has seen significant progress over the last twenty years, and this book collects and synthesizes existing research previously only available in widely scattered individual papers, offering an accessible guide to the latest information on self-reconfigurable robots for researchers and students interested in the field. Self-Reconfigurable Robots focuses on conveying the intuition behind the design and control of self-reconfigurable robots rather than technical details. Suggestions for further reading refer readers to the underlying sources of technical information. The book includes descriptions of existing robots and a brief history of the field; discussion of module design considerations, including module geometry, connector design, and computing and communication infrastructure; an in-depth presentation of strategies for controlling self-reconfiguration and locomotion; and exploration of future research challenges.

Significant progress has been made on nonlinear control systems in the past two decades. However, many of the existing nonlinear control methods cannot be readily used to cope with communication and networking issues without nontrivial modifications. For example, small quantization errors may cause the performance of a "well-designed" nonlinear control system to deteriorate. Motivated by the need for new tools to solve complex problems resulting from smart power grids, biological processes, distributed computing networks, transportation networks, robotic systems, and other cutting-edge control applications, Nonlinear Control of Dynamic Networks tackles newly arising theoretical and real-world challenges for stability analysis and control design, including nonlinearity, dimensionality, uncertainty, and information constraints as well as behaviors stemming from quantization, data-sampling, and impulses. Delivering a systematic review of the nonlinear small-gain theorems, the text: Supplies novel cyclic-small-gain theorems for large-scale nonlinear dynamic networks Offers a cyclic-small-gain framework for nonlinear control with static or dynamic quantization Contains a combination of cyclic-small-gain and set-valued map designs for robust control of nonlinear uncertain systems subject to sensor noise Presents a cyclic-small-gain result in directed graphs and distributed control of nonlinear multi-agent systems with fixed or dynamically changing topology Based on the authors’ recent research, Nonlinear Control of Dynamic Networks provides a unified framework for robust, quantized, and distributed control under information constraints. Suggesting avenues for further exploration, the book encourages readers to take into consideration more communication and networking issues in control designs to better handle the arising challenges.

Through expanded intelligence, the use of robotics has fundamentally transformed a variety of fields, including manufacturing, aerospace, medicine, social services, and agriculture. Continued research on robotic design is critical to solving various dynamic obstacles individuals, enterprises, and humanity at large face on a daily basis. Robotic Systems: Concepts, Methodologies, Tools, and Applications is a vital reference source that delves into the current issues, methodologies, and trends relating to advanced robotic technology in the modern world. Highlighting a range of topics such as mechatronics, cybernetics, and human-computer interaction, this multi-volume book is ideally designed for robotics engineers, mechanical engineers, robotics technicians, operators, software engineers, designers, programmers, industry professionals, researchers, students, academicians, and computer practitioners seeking current research on developing innovative ideas for intelligent and autonomous robotics systems.

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.
The emergence of wireless robotic systems has provided new perspectives on technology. With the combination of disciplines such as robotic systems, ad hoc networking, telecommunications and more, mobile ad hoc robots have proven essential in aiding future possibilities of technology. Mobile Ad Hoc Robots and Wireless Robotic Systems: Design and Implementation aims to introduce robotic theories, wireless technologies, and routing applications involved in the development of mobile ad hoc robots. This reference source brings together topics on the communication and control of network ad hoc robots, describing how they work together to carry out coordinated functions.
This brief describes the coordinated control of groups of robots using only sensory input – and no direct external commands. Furthermore, each robot employs the same local strategy, i.e., there are no leaders, and the text also deals with decentralized control, allowing for cases in which no single robot can sense all the others. One can get intuition for the problem from the natural world, for example, flocking birds. How do they achieve and maintain their flying formation? Recognizing their importance as the most basic coordination tasks for mobile robot networks, the brief details flocking and rendezvous. They are shown to be physical illustrations of emergent behaviors with global consensus arising from local interactions. The authors extend the consideration of these fundamental ideas to describe their operation in flying robots

and prompt readers to pursue further research in the field. Flocking and Rendezvous in Distributed Robotics will provide graduate students a firm grounding in the subject, while also offering an authoritative reference work for more experienced workers seeking a brief but thorough treatment of an area that has rapidly gained in interest.

Studies on robotics applications have grown substantially in recent years, with swarm robotics being a relatively new area of research. Inspired by studies in swarm intelligence and robotics, swarm robotics facilitates interactions between robots as well as their interactions with the environment. The Handbook of Research on Design, Control, and Modeling of Swarm Robotics is a collection of the most important research achievements in swarm robotics thus far, covering the growing areas of design, control, and modeling of swarm robotics. This handbook serves as an essential resource for researchers, engineers, graduates, and senior undergraduates with interests in swarm robotics and its applications.

This book illustrates basic principles, along with the development of the advanced algorithms, to realize smart robotic systems. It speaks to strategies by which a robot (manipulators, mobile robot, quadrotor) can learn its own kinematics and dynamics from data. In this context, two major issues have been dealt with; namely, stability of the systems and experimental validations. Learning algorithms and techniques as covered in this book easily extend to other robotic systems as well. The book contains MATLAB- based examples and c-codes under robot operating systems (ROS) for experimental validation so that readers can replicate these algorithms in robotics platforms.

The second edition of this handbook provides a state-of-the-art overview on the various aspects in the rapidly developing field of robotics. Reaching for the human frontier, robotics is vigorously engaged in the growing challenges of new emerging domains. Interacting, exploring, and working with humans, the new generation of robots will increasingly touch people and their lives. The credible prospect of practical robots among humans is the result of the scientific endeavour of a half a century of robotic developments that established robotics as a modern scientific discipline. The ongoing vibrant expansion and strong growth of the field during the last decade has fueled this second edition of the Springer Handbook of Robotics. The first edition of the handbook soon became a landmark in robotics publishing and won the American Association of Publishers PROSE Award for Excellence in Physical Sciences & Mathematics as well as the organization's Award for Engineering & Technology. The second edition of the handbook, edited by two internationally renowned scientists with the support of an outstanding team of seven part editors and more than 200 authors, continues to be an authoritative reference for robotics researchers, newcomers to the field, and scholars from related disciplines. The contents have been restructured to achieve four main objectives: the enlargement of foundational topics for robotics, the enlightenment of design of various types of robotic systems, the extension of the treatment on robots moving in the environment, and the enrichment of advanced robotics applications. Further to an extensive update, fifteen new chapters have been introduced on emerging topics, and a new generation of authors have joined the handbook's team. A novel addition to the second edition is a comprehensive collection of multimedia references to more than 700 videos, which bring valuable insight into the contents. The videos can be viewed directly augmented into the text with a smartphone or tablet using a unique and specially designed app. Springer Handbook of Robotics Multimedia Extension Portal: http://handbookofrobotics.org/

Control engineering seeks to understand physical systems, using mathematical modeling, in terms of inputs, outputs and various components with different behaviors. It has an essential role in a wide range of control systems, from household appliances to space flight. This book provides an in-depth view of the technologies that are implemented in most varieties of modern industrial control engineering. A solid grounding is provided in traditional control techniques, followed by detailed examination of modern control techniques such as real-time, distributed, robotic, embedded, computer and wireless control technologies. For each technology, the book discusses its full profile, from the field layer and the control layer to the operator layer. It also includes all the interfaces in industrial control systems: between controllers and systems; between different layers; and between operators and systems. It not only describes the details of both real-time operating systems and distributed operating systems, but also provides coverage of the microprocessor boot code, which other books lack. In addition to working principles and operation mechanisms, this book emphasizes the practical issues of components, devices and hardware circuits, giving the specification parameters, install procedures, calibration and configuration methodologies needed for engineers to put the theory into practice. Documents all the key technologies of a wide range of industrial control systems Emphasizes practical application and methods alongside theory and principles An ideal reference for practicing engineers needing to further their understanding of the latest industrial control concepts and techniques

This self-contained introduction to the distributed control of robotic networks offers a distinctive blend of computer science and control theory. The book presents a broad set of tools for understanding coordination algorithms, determining their correctness, and assessing their complexity; and it analyzes various cooperative strategies for tasks such as consensus, rendezvous, connectivity maintenance, deployment, and boundary estimation. The unifying theme is a formal model for robotic networks that explicitly incorporates their communication, sensing, control, and processing capabilities--a model that in turn leads to a common formal language to describe and analyze coordination algorithms. Written for first- and second-year graduate students in control and robotics, the book will also be useful to researchers in control theory, robotics, distributed algorithms, and automata theory. The book provides explanations of the basic concepts and main results, as well as numerous examples and exercises. Self-contained exposition of graph-theoretic concepts, distributed algorithms, and complexity measures for processor networks with fixed interconnection topology and for robotic networks with position-dependent interconnection topology Detailed treatment of averaging and consensus algorithms interpreted as linear iterations on synchronous networks Introduction of geometric notions such as partitions, proximity graphs, and multicenter functions Detailed treatment of motion coordination algorithms for deployment, rendezvous, connectivity maintenance, and boundary estimation

This book introduces various coverage control problems for mobile sensor networks including barrier, sweep and blanket. Unlike many existing algorithms, all of the robotic sensor and actuator motion algorithms developed in the book are fully decentralized or distributed, computationally efficient, easily implementable in engineering practice and based only on information on the closest neighbours of each mobile sensor and actuator and local information about the environment. Moreover, the mobile robotic sensors have no prior information about the environment in which they operation. These various types of coverage problems have never been covered before by a single book in a systematic way. Another topic of this book is the study of mobile robotic sensor and actuator networks. Many modern engineering applications include the use of sensor and actuator networks to provide efficient and effective monitoring and control of industrial and environmental processes. Such mobile sensor and actuator networks are able to achieve improved performance and efficient monitoring together with reduction in power consumption and production cost. This thesis contributes to the development of a cooperative control theory for homogeneous and heterogeneous multi-agent systems consisting of identical and non-identical dynamical agents, respectively. The goal is to explain fundamental effects of non-identical agent dynamics on the behavior of a distributed system and, primarily, to develop suitable control design methods for a wide range of multi-agent coordination problems. Output synchronization problems as well as cooperative disturbance rejection and reference tracking problems in multi-agent systems are investigated. Suitable controller design methods for networks consisting of identical or non-identical linear time-invariant systems, linear parameter-varying systems, and selected classes of nonlinear systems are developed. These controller design methods provide a solution to a wide variety of distributed coordination and cooperative control scenarios. Distributed Control Applications: Guidelines, Design Patterns, and Application Examples with the IEC 61499 discusses the IEC 61499 reference architecture for distributed and reconfigurable control and its adoption by industry. The book provides design patterns, application guidelines, and rules for designing distributed control applications based on the IEC 61499 reference model. Moreover, examples from various industrial domains and laboratory environments are introduced and explored.

This book is the volume of the proceedings for the 17th Edition of ISER. The goal of ISER (International Symposium on Experimental Robotics) symposia is to provide a single-track forum on the current developments and new directions of experimental robotics. The series has traditionally attracted a wide readership of researchers and practitioners interested to the advances and innovations of robotics technology. The 54 contributions cover a wide range of topics in robotics and are organized in 9 chapters: aerial robots, design and prototyping, field robotics, human-robot interaction, machine learning, mapping and localization, multi-robots, perception, planning and control. Experimental validation of algorithms, concepts, or techniques is the common thread running through this large research collection.

This work examines the challenges of distributed map merging and localization in multi-robot systems, which enables robots to acquire the knowledge of their surroundings needed to carry out coordinated tasks. After identifying the main issues associated with this problem, each chapter introduces a different distributed strategy for solving them. In addition to presenting a review of distributed algorithms for perception in localization and map merging, the text also provides the reader with the necessary tools for proposing new solutions to problems of multi-robot perception, as well as other interesting topics related to multi-robot scenarios. The coverage is largely self-contained, supported by numerous explanations and demonstrations, although references for further study are also supplied. The reader will not require any prior background knowledge, other than a basic understanding of mathematics at a graduate-student level.

This book nds its origin in the WIDE PhD School on Networked Control Systems, which we organized in July 2009 in Siena, Italy. Having gathered experts on all the aspects of networked control systems, it was a small step to go from the summer school to the book, certainly given the enthusiasm of the lecturers at the school. We felt that a book collecting overviewson the important developmentsand open pr- lems in the eld of networked control systems could stimulate and support future research in this appealing area. Given the tremendouscurrentinterests in distributed control exploiting wired and wireless communication networks, the time seemed to be right for the book that lies now in front of you. The goal of the book is to set out the core techniques and tools that are ava- able for the modeling, analysis and design of networked control systems. Roughly speaking, the book consists of three parts. The rst part presents architectures for distributed control systems and models of wired and wireless communication n- works. In particular, in the rst chapter important technological and architectural aspects on distributed control systems are discussed. The second chapter provides insight in the behavior of communication channels in terms of delays, packet loss and information constraints leading to suitable modeling paradigms for commu- cation networks.

This volume of proceedings includes 32 original contributions presented at the 12th International Symposium on Distributed Autonomous Robotic Systems (DARS 2014), held in November 2014. The selected papers in this volume are authored by leading researchers from Asia, Australia, Europe, and the Americas, thereby providing a broad coverage and perspective of the state-of-the-art technologies, algorithms, system architectures, and applications in distributed robotic systems.

The book aims to equalize the theoretical involvement with industrial practicality and build a bridge between academia and industry by reducing the mathematical difficulties. It provides an overview of distributed control and distributed optimization theory, followed by specific details on industrial applications to smart grid systems, with a special focus on micro grid systems. Each of the chapters is written and organized with an introductory section tailored to provide the essential background of the theories required. The text includes industrial applications to realistic renewable energy systems problems and illustrates the application of proposed toolsets to control and optimization of smart grid systems.

This self-contained introduction to the distributed control of robotic networks offers a distinctive blend of computer science and control theory. The book presents a broad set of tools for understanding coordination algorithms, determining their correctness, and assessing their complexity; and it analyzes various cooperative strategies for tasks such as consensus, rendezvous, connectivity maintenance, deployment, and boundary estimation. The unifying theme is a formal model for robotic networks that explicitly incorporates their communication, sensing, control, and processing capabilities--a.
This book presents a unified frequency-domain method for the analysis of distributed control systems. The following important topics are discussed by using the proposed frequency-domain method: (1) Scalable stability criteria of networks of distributed control systems; (2) Effect of heterogeneous delays on the stability of a network of distributed control system; (3) Stability of Internet congestion control algorithms; and (4) Consensus in multi-agent systems. This book is ideal for graduate students in control, networking and robotics, as well as researchers in the fields of control theory and networking who are interested in learning and applying distributed control algorithms or frequency-domain analysis methods.
The present book includes a set of selected papers from the third “International Conference on Informatics in Control Automation and Robotics” (ICINCO 2006), held in Setúbal, Portugal, from 1 to 5 August 2006, sponsored by the Institute for Systems and Technologies of Information, Control and Communication (INSTICC). The conference

was organized in three simultaneous tracks: “Intelligent Control Systems and Optimization”, “Robotics and Automation” and “Systems Modeling, Signal Processing and Control”. The book is based on the same structure. Although ICINCO 2006 received 309 paper submissions, from more than 50 different countries in all continents, only 31 where accepted as full papers. From those, only 23 were selected for inclusion in this book, based on the classifications provided by the Program Committee. The selected papers also reflect the interdisciplinary nature of the conference. The diversity of topics is an important feature of this conference, enabling an overall perception of several important scientific and technological trends. These high quality standards will be maintained and reinforced at ICINCO 2007, to be held in Angers, France, and in future editions of this conference.

Discrete Networked Dynamic Systems: Analysis and Performance provides a high-level treatment of a general class of linear discrete-time dynamic systems interconnected over an information network, exchanging relative state measurements or output measurements. It presents a systematic analysis of the material and provides an account to the math development in a unified way. The topics in this book are structured along four dimensions: Agent, Environment, Interaction, and Organization, while keeping global (system-centered) and local (agent-centered) viewpoints. The focus is on the wide-sense consensus problem in discrete networked dynamic systems. The authors rely heavily on algebraic graph theory and topology to derive their results.

It is known that graphs play an important role in the analysis of interactions between multiagent/distributed systems. Graph-theoretic analysis provides insight into how topological interactions play a role in achieving coordination among agents. Numerous types of graphs exist in the literature, depending on the edge set of G. A simple graph has no self-loop or edges. Complete graphs are simple graphs with an edge connecting any pair of vertices. The vertex set in a bipartite graph can be partitioned into disjoint non-empty vertex sets, whereby there is an edge connecting every vertex in one set to every vertex in the other set. Random graphs have fixed vertex sets, but the edge set exhibits stochastic behavior modeled by probability functions. Much of the studies in coordination control are based on deterministic/fixed graphs, switching graphs, and random graphs. This book addresses advanced analytical tools for characterization control, estimation and design of networked dynamic systems over fixed, probabilistic and time-varying graphs Provides coherent results on adopting a set-theoretic framework for critically examining problems of the analysis, performance and design of discrete distributed systems over graphs Deals with both homogeneous and heterogeneous systems to guarantee the generality of design results
Examines new cooperative control methodologies tailored to real-world applications in various domains such as in communication systems, physics systems, and multi-robotic systems Provides the fundamental mechanism for solving collective behaviors in naturally-occurring systems as well as cooperative behaviors in man-made systems

Discusses cooperative control methodologies using real-world applications, including semi-conductor laser arrays, mobile sensor networks, and multi-robotic systems Includes results from the research group at the Stevens Institute of Technology to show how advanced control technologies can impact challenging issues, such as high energy systems and oil spill monitoring

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.

Wireless ad hoc sensor networks has recently become a very active research subject. Achieving efficient, fault-tolerant realizations of very large, highly dynamic, complex, unconventional networks is a real challenge for abstract modelling, algorithmic design and analysis, but a solid foundational and theoretical background seems to be lacking. This book presents high-quality contributions by leading experts worldwide on the key algorithmic and complexity-theoretic aspects of wireless sensor networks. The intended audience includes researchers and graduate students working on sensor networks, and the broader areas of wireless networking and distributed computing, as well as practitioners in the relevant application areas. The book can also serve as a text for advanced courses and seminars.

Through expanded intelligence, the use of robotics has fundamentally transformed the business industry. Providing successful techniques in robotic design allows for increased autonomous mobility, which leads to a greater productivity and production level. Rapid Automation: Concepts, Methodologies, Tools, and Applications provides innovative insights into the state-of-the-art technologies in the design and development of robotics and their real-world applications in business processes. Highlighting a range of topics such as workflow automation tools, human-computer interaction, and swarm robotics, this multi-volume book is ideally designed for computer engineers, business managers, robotic developers, business and IT professionals, academicians, and researchers.

The area of analysis and control of mechanical systems using differential geometry is flourishing. This book collects many results over the last decade and provides a comprehensive introduction to the area.

Distributed robotics is a rapidly growing, interdisciplinary research area lying at the intersection of computer science, communication and control systems, and electrical and mechanical engineering. The goal of the Symposium on Distributed Autonomous

Robotic Systems (DARS) is to exchange and stimulate research ideas to realize advanced distributed robotic systems. This volume of proceedings includes 43 original contributions presented at the Tenth International Symposium on Distributed Autonomous Robotic Systems (DARS 2010), which was held in November 2010 at the École Polytechnique Fédérale de Lausanne (EPFL), Switzerland. The selected papers in this volume are authored by leading researchers from Asia, Europa, and the Americas, thereby providing a broad coverage and perspective of the state-of-the-art technologies, algorithms, system architectures, and applications in distributed robotic systems. The book is organized into four parts, each representing one critical and long-term research thrust in the multi-robot community: distributed sensing (Part I); localization, navigation, and formations (Part II); coordination algorithms and formal methods (Part III); modularity, distributed manipulation, and platforms (Part IV).
There has been great interest in "universal controllers" that mimic the functions of human processes to learn about the systems they are controlling on-line so that performance improves automatically. Neural network controllers are derived for robot manipulators in a variety of applications including position control, force control, link flexibility stabilization and the management of high-frequency joint and motor dynamics. The first chapter provides a background on neural networks and the second on dynamical systems and control. Chapter three introduces the robot control problem and standard techniques such as torque, adaptive and robust control. Subsequent chapters

give design techniques and Stability Proofs For NN Controllers For Robot Arms, Practical Robotic systems with high frequency vibratory modes, force control and a general class of non-linear systems. The last chapters are devoted to discrete- time NN controllers. Throughout the text, worked examples are provided.

The study of what can be computed by a team of autonomous mobile robots, originally started in robotics and AI, has become increasingly popular in theoretical computer science (especially in distributed computing), where it is now an integral part of the investigations on computability by mobile entities. The robots are identical computational entities located and able to move in a spatial universe; they operate without explicit communication and are usually unable to remember the past; they are extremely simple, with limited resources, and individually quite weak. However, collectively the robots are capable of performing complex tasks, and form a system with desirable fault-tolerant and self-stabilizing properties. The research has been concerned with the computational aspects of such systems. In particular, the focus has been on the minimal capabilities that the robots should have in order to solve a problem. This book focuses on the recent algorithmic results in the field of distributed computing by oblivious mobile robots (unable to remember the past). After introducing the computational model with its nuances, we focus on basic coordination problems: pattern formation, gathering, scattering, leader election, as well as on dynamic tasks such as flocking. For each of these problems, we provide a snapshot of the state of the art, reviewing the existing algorithmic results. In doing so, we outline solution techniques, and we analyze the impact of the different assumptions on the robots' computability power. Table of Contents: Introduction / Computational Models / Gathering and Convergence / Pattern Formation / Scatterings and Coverings / Flocking / Other Directions

Focused on solving competition-based problems, this book designs, proposes, develops, analyzes and simulates various neural network models depicted in centralized and distributed manners. Specifically, it defines four different classes of centralized models for investigating the resultant competition in a group of multiple agents. With regard to distributed competition with limited communication among agents, the book presents the first distributed WTA (Winners Take All) protocol, which it subsequently extends to the distributed coordination control of multiple robots. Illustrations, tables, and various simulative examples, as well as a healthy mix of plain and professional language, are used to explain the concepts and complex principles involved. Thus, the book provides readers in neurocomputing and robotics with a deeper understanding of the neural network approach to competition-based problem-solving, offers them an accessible introduction to modeling technology and the distributed coordination control of redundant robots, and equips them to use these technologies and approaches to solve concrete scientific and engineering problems.

These lecture notes provide a mathematical introduction to multi-agent dynamical systems, including their analysis via algebraic graph theory and their application to engineering design problems. The focus is on fundamental dynamical phenomena over interconnected network systems, including consensus and disagreement in averaging systems, stable equilibria in compartmental flow networks, and synchronization in coupled oscillators and networked control systems. The theoretical results are complemented by numerous examples arising from the analysis of physical and natural systems and from the design of network estimation, control, and optimization systems.