Passivity Based Control And Estimation In Networked Robotics Communications And Control Engineering

This Encyclopedia of Control Systems, Robotics, and Automation is a component of the global Encyclopedia of Life Support Systems EOLSS, which is an integrated compendium of twenty one Encyclopedias. This 22-volume set contains 240 chapters, each of size 5000-30000 words, with perspectives, applications and extensive illustrations. It is the only publication of its kind carrying state-of-the-art knowledge in the fields of Control Systems, Robotics, and Automation and is aimed, by virtue of the several applications, at the following five major target audiences: University and College Students, Educators, Professional Practitioners, Research Personnel and Policy Analysts, Managers, and Decision Makers and NGOs

This textbook explains the principles of fuzzy systems in some depth together with information useful in realizing them within computational processes. The various algorithms and example problem solutions are a well-balanced and pertinent aid for research projects, laboratory work and graduate study. In addition to its worked examples, the book also uses end-of-chapter exercises as an instructional aid with a downloadable solutions manual available to instructors. The content of the book is developed and extended from material taught for four years in the author's classes. The text provides a broad overview of fuzzy control, estimation and fault diagnosis. It ranges over various classes of target system and modes of control and then turns to filtering, stabilization, and fault detection and diagnosis. Applications, simulation tools and an appendix on algebraic inequalities complete a unified approach to the analysis of single and interconnected fuzzy systems. Fuzzy Control, Estimation and Fault Detection is a guide for final-year undergraduate and graduate students of electrical and mechanical engineering, computer science and information technology, and will also be instructive for professionals in the information technology sector.

Passivity-based Model Predictive Control for Mobile Vehicle Navigation represents a complete theoretical approach to the adoption of passivity-based model predictive control (MPC) for autonomous vehicle navigation in both indoor and outdoor environments. The brief also introduces analysis of the worst-case scenario that might occur during the task execution. Some of the questions answered in the text include: • how to use an MPC optimization framework for the mobile vehicle navigation approach; • how to guarantee safe task completion even in complex environments including obstacle avoidance and sideslip and rollover avoidance; and • what to expect in the worst-case scenario in which the roughness of the terrain leads the algorithm to generate the longest possible path to the goal. The passivity-based MPC approach provides a framework in which a wide range of complex vehicles can be accommodated to obtain a safer and more realizable tool during the path-planning stage. During task execution, the optimization step is continuously repeated to take into account new local sensor measurements. These ongoing changes make the path generated rather robust in comparison with techniques that fix the entire path prior to task execution. In addition to researchers working in MPC, engineers interested in vehicle path planning for a number of purposes: rescued mission in hazardous environments; humanitarian demining; agriculture; and even planetary exploration, will find this SpringerBrief to be instructive and helpful.

The design of nonlinear controllers for mechanical systems has been an ex tremely active area of research in the last two decades. From a theoretical point of view, this attention can be attributed to their interesting dynamic behavior, which makes them suitable benchmarks for nonlinear control the oreticians. On the other hand, recent technological advances have produced many real-world engineering applications that require the automatic con trol of mechanical systems. the mechanism for de Often, Lyapunov-based techniques are utilized as veloping different nonlinear control structures for mechanical systems. The allure of the Lyapunov-based framework for mechanical system control de sign can most likely be assigned to the fact that Lyapunov function candi dates can often be crafted from physical insight into the mechanics of the system. That is, despite the nonlinearities, couplings, and/or the flexible effects associated with the system, Lyapunov-based techniques can often be used to analyze the stability of the closed-loop system by using an energy like function as the Lyapunov function candidate. In practice, the design procedure often tends to be an iterative process that results in the death of many trees. That is, the controller and energy-like function are often constructed in concert to foster an advantageous stability property and/or robustness property. Fortunately, over the last 15 years, many system the ory and control researchers have labored in this area to produce various design tools that can be applied in a variety of situations.

The essence of this work is the control of electromechanical systems, such as manipulators, electric machines, and power converters. The common thread that links together the results presented here is the passivity property, which is at

present in numerous electrical and mechanical systems, and which has great relevance in control engineering at this time. Amongst other topics, the authors cover: Euler-Lagrange Systems, Mechanical Systems, Generalised AC Motors, Induction Motor Control, Robots with AC Drives, and Perspectives and Open Problems. The authors have extensive experience of research and application in the field of control of electromechanical systems, which they have summarised here in this self-contained volume. While written in a strictly mathematical way, it is also elementary, and will be accessible to a wide-ranging audience, including graduate students as well as practitioners and researchers in this field.
A New Edition Featuring Case Studies and Examples of the Fundamentals of Robot Kinematics, Dynamics, and Control In the 2nd Edition of Robot Modeling and Control, students will cover the theoretical fundamentals and the latest technological advances in robot kinematics. With so much advancement in technology, from robotics to motion planning, society can implement more powerful and dynamic algorithms than ever before. This in-depth reference guide educates readers in four distinct parts; the first two serve as a guide to the fundamentals of robotics and motion control, while the last two dive more in-depth into control theory and nonlinear system analysis. With the new edition, readers gain access to new case studies and

thoroughly researched information covering topics such as: ? Motion-planning, collision avoidance, trajectory optimization, and control of robots ? Popular topics within the robotics industry and how they apply to various technologies ? An expanded set of examples, simulations, problems, and case studies ? Open-ended suggestions for students to apply the knowledge to real-life situations A four-part reference essential for both undergraduate and graduate students, Robot Modeling and Control serves as a foundation for a solid education in robotics and motion planning.
This book examines the signal processing perspective in haptic teleoperation systems. This text covers the topics of prediction, estimation, architecture, data compression and error correction that can be applied to haptic teleoperation systems. The authors begin with an overview of haptic teleoperation systems, then look at a Bayesian approach to haptic teleoperation systems. They move onto a discussion of haptic data compression, haptic data digitization and forward error correction.
Modern power electronic converters are involved in a very broad spectrum of applications: switched-mode power supplies, electrical-machine-motion-control, active power filters, distributed power generation, flexible AC transmission systems, renewable energy conversion systems and vehicular technology, among them. Power Electronics Converters

Modeling and Control teaches the reader how to analyze and model the behavior of converters and so to improve their design and control. Dealing with a set of confirmed algorithms specifically developed for use with power converters, this text is in two parts: models and control methods. The first is a detailed exposition of the most usual power converter models: · switched and averaged models; · small/large-signal models; and · time/frequency models. The second focuses on three groups of control methods: · linear control approaches normally associated with power converters; · resonant controllers because of their significance in grid-connected applications; and · nonlinear control methods including feedback linearization, stabilizing, passivity-based, and variable-structure control. Extensive case-study illustration and end-of-chapter exercises reinforce the study material. Power Electronics Converters Modeling and Control addresses the needs of graduate students interested in power electronics, providing a balanced understanding of theoretical ideas coupled with pragmatic tools based on control engineering practice in the field. Academics teaching power electronics will find this an attractive course text and the practical points make the book useful for self tuition by engineers and other practitioners wishing to bring their knowledge up to date.

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Port-Hamiltonian Systems Theory: An Introductory Overview provides a concise and easily accessible description of the foundations underpinning the subject and emphasizes novel developments in the field, which will be of interest to a broad range of researchers.

One of the fundamental requirements for the success of a robot task is the capability to handle interaction between manipulator and environment. The quantity that describes the state of interaction more effectively is the contact force at the manipulator's end effector. High values of contact force are generally undesirable since they may stress both the manipulator and the manipulated object; hence the need to seek for effective force control strategies. The book provides a theoretical and experimental treatment of robot interaction control. In the framework of model-based operational space control, stiffness control and impedance control are presented as the basic strategies for indirect force control; a key feature is the coverage of six-degree-of-freedom interaction tasks and manipulator kinematic redundancy. Then, direct force control strategies are presented which are obtained from motion control schemes suitably modified by the closure of an outer force regulation feedback loop. Finally, advanced force and position control strategies are presented which include passivity-based, adaptive and output feedback control schemes. Remarkably, all control schemes are experimentally tested on a setup consisting of a seven-joint industrial robot with open control architecture and force/torque sensor. The topic of robot force control is not treated in depth in robotics textbooks, in spite of its crucial importance for practical manipulation tasks. In the few books addressing this topic, the material is often limited to single-degree-of-freedom tasks. On the other hand, several results are available in the robotics literature but no dedicated monograph exists. The book is thus aimed at filling this gap by providing a theoretical and experimental treatment of robot force control. Algebraic Identification and Estimation Methods in Feedback Control Systems presents a model-based algebraic approach to online parameter and state estimation in uncertain dynamic feedback control systems. This approach evades the mathematical intricacies of the traditional stochastic approach, proposing a direct model-based scheme with several easy-to-implement computational advantages. The approach can be used with continuous and discrete, linear and nonlinear, mono-variable and multi-variable systems. The estimators based on this approach are not of asymptotic nature, and do not require any statistical knowledge of the corrupting noises to achieve good performance in a noisy environment. These estimators are fast, robust to structured perturbations, and easy to combine with classical or sophisticated control laws. This book uses module theory, differential algebra, and operational calculus in an easy-to-understand manner and also details how to apply these in the context of feedback control systems. A wide variety of examples, including mechanical systems, power converters, electric motors, and chaotic systems, are also included to illustrate the algebraic methodology. Key features: Presents a radically new approach to online parameter and state estimation. Enables the reader to master the use and understand the consequences of the highly theoretical differential algebraic viewpoint in control systems theory. Includes examples in a variety of physical applications with experimental results. Covers the latest developments and applications. Algebraic Identification and Estimation Methods in Feedback Control Systems is a comprehensive reference for researchers and practitioners working in the area of automatic control, and is also a useful source of information for graduate and undergraduate students.

This second edition of Dissipative Systems Analysis and Control has been substantially reorganized to accommodate new material and enhance its pedagogical features. It examines linear and nonlinear systems with examples of both in each chapter. Also included are some infinite-dimensional and nonsmooth examples. Throughout, emphasis is placed on the use of the dissipative properties of a system for the design of stable feedback control laws.

This monograph investigates a practical way to achieve robust motion control and state estimation (Kalman filtering) of mechanical systems, which is a promising approach in terms of the perturbation compensator. The book presents novel approaches for design and analysis of perturbation observers as well as an extension to robust motion control and robust state estimation. The book is written in a self-contained manner including experimental results in each chapter clearly validating the developed theories.

This book gives readers in-depth know-how on methods of state estimation for nonlinear control systems. It starts with an introduction to dynamic control systems and system states and a brief description of the Kalman filter.

In the following chapters, various state estimation techniques for nonlinear systems are discussed, including the extended, unscented and cubature Kalman filters. The cubature Kalman filter and its variants are introduced in particular detail because of their efficiency and their ability to deal with systems with Gaussian and/or non-Gaussian noise. The book also discusses information-filter and square-root-filtering algorithms, useful for state estimation in some real-time control system design problems. A number of case studies are included in the book to illustrate the application of various nonlinear filtering algorithms. Nonlinear Filtering is written for academic and industrial researchers, engineers and research students who are interested in nonlinear control systems analysis and design. The chief features of the book include: dedicated coverage of recently developed nonlinear, Jacobian-free, filtering algorithms; examples illustrating the use of nonlinear filtering algorithms in real-world applications; detailed derivation and complete algorithms for nonlinear filtering methods, which help readers to a fundamental understanding and easier coding of those algorithms; and MATLAB® codes associated with case-study applications, which can be downloaded from the Springer Extra Materials website.
Explore the foundational and advanced subjects associated with proportional-integral-derivative controllers from leading authors in the field In PID Passivity-Based Control of Nonlinear Systems with Applications, expert researchers and authors Drs. Romeo Ortega, Jose Guadalupe Romero, Pablo Borja,

and Alejandro Donaire deliver a comprehensive and detailed discussion of the most crucial and relevant concepts in the analysis and design of proportional-integral-derivative controllers using passivity techniques. The accomplished authors present a formal treatment of the recent research in the area and offer readers practical applications of the developed methods to physical systems, including electrical, mechanical, electromechanical, power electronics, and process control. The book offers the material with minimal mathematical background, making it relevant to a wide audience. Familiarity with the theoretical tools reported in the control systems literature is not necessary to understand the concepts contained within. You'll learn about a wide range of concepts, including disturbance rejection via PID control, PID control of mechanical systems, and Lyapunov stability of PID controllers. Readers will also benefit from the inclusion of: A thorough introduction to a class of physical systems described in the port-Hamiltonian form and a presentation of the systematic procedures to design PID-PBC for them An exploration of the applications to electrical, electromechanical, and process control systems of Lyapunov stability of PID controllers Practical discussions of the regulation and tracking of bilinear systems via PID control and their application to power electronics and thermal process control A concise treatment of the characterization of passive outputs, incremental models, and Port Hamiltonian and Euler-Lagrange systems Perfect for senior undergraduate and graduate students studying control systems, PID

Passivity-Based Control will also earn a place in the libraries of engineers who practice in this area and seek a one-stop and fully updated reference on the subject.
This book gathers contributions from a multidisciplinary research team comprised of control engineering and economics researchers and formed to address a central interdisciplinary social issue, namely economically enabled energy management. The book’s primary focus is on achieving optimal energy management that is viable from both an engineering and economic standpoint. In addition to the theoretical results and techniques presented, several chapters highlight experimental case studies, which will benefit academic researchers and practitioners alike. The first three chapters present comprehensive overviews of respective social contexts, underscore the pressing need for economically efficient energy management systems and academic work on this emerging research topic, and identify fundamental differences between approaches in control engineering and economics. In turn, the next three chapters (Chapters 4–6) provide economics-oriented approaches to the subject. The following five chapters (Chapters 7–11) address optimal energy market design, integrating both physical and economic models. The book’s last three chapters (Chapters 12–14) mainly focus on the engineering aspects of next-generation energy management, though economic factors are also shown to play important roles.
Highlighting the control of networked robotic systems, this book synthesizes a unified passivity-based approach to an emerging cross-disciplinary subject. Thanks to this

unified approach, readers can access various state-of-the-art research fields by studying only the background foundations associated with passivity. In addition to the theoretical results and techniques, the authors provide experimental case studies on testbeds of robotic systems including networked haptic devices, visual robotic systems, robotic network systems and visual sensor network systems. The text begins with an introduction to passivity and passivity-based control together with the other foundations needed in this book. The main body of the book consists of three parts. The first examines how passivity can be utilized for bilateral teleoperation and demonstrates the inherent robustness of the passivity-based controller against communication delays. The second part emphasizes passivity's usefulness for visual feedback control and estimation. Convergence is rigorously proved even when other passive components are interconnected. The passivity approach is also differentiated from other methodologies. The third part presents the unified passivity-based control-design methodology for multi-agent systems. This scheme is shown to be either immediately applicable or easily extendable to the solution of various motion coordination problems including 3-D attitude/pose synchronization, flocking control and cooperative motion estimation. Academic researchers and practitioners working in systems and control and/or robotics will appreciate the potential of the elegant and novel approach to the control of networked robots presented here. The limited background required and the case-study work described also make the text appropriate for

and, it is hoped, inspiring to students.
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.
Standalone (off-grid) renewable energy systems supply electricity in places where there is no access to a standard electrical grid. These systems may include photovoltaic generators, wind turbines, hydro turbines or any other renewable electrical generator. Usually, this kind of system includes electricity storage (commonly lead-acid batteries, but also other types of storage can be used). In some cases, a backup generator (usually powered by fossil fuel, diesel or gasoline) is part of the hybrid system. The modelling of the components, the control of the system and the simulation of the performance of the whole system are necessary to evaluate the system technically and economically. The

optimization of the sizing and/or the control is also an important task in this kind of system.
This book deals with the analysis and feedback control of dissipative dynamical systems. It presents the background of dissipative systems theory. Linear as well as nonlinear systems are treated, and many examples are given throughout the chapters. Some infinite dimensional and non-smooth examples are also included. The emphasis is put on the application towards the design of stable feedback control laws. Then the theory is illustrated on physical examples; (Lagrangian and Hamiltonian systems are thoroughly studied, as well as adaptive control). It is shown how the dissipativity properties of a system can be used in the design of stable feedback controllers. Some experimental results are presented which corroborate the theoretical developments. This monograph is primarily for readers who wish to get aquainted with Dissipative Systems Theory, and its uses in Systems and Control and Robotics. It constitutes an advanced introduction to the topic, and is the first volume ever published which is dedicated entirely to this subject.
Control Systems: Classical, Modern, and AI-Based Approaches provides a broad and comprehensive study of the principles, mathematics, and applications for those studying basic control in mechanical, electrical, aerospace, and other engineering disciplines. The text builds a strong mathematical foundation of control theory of linear, nonlinear, optimal, model predictive, robust, digital, and adaptive control systems, and it addresses applications in several emerging areas, such as aircraft, electro-mechanical, and some nonengineering systems: DC motor control, steel beam thickness control, drum boiler, motional control system, chemical reactor, head-disk assembly, pitch control of an aircraft, yaw-damper control, helicopter control, and tidal power control. Decentralized control, game-theoretic control,

and control of hybrid systems are discussed. Also, control systems based on artificial neural networks, fuzzy logic, and genetic algorithms, termed as AI-based systems are studied and analyzed with applications such as auto-landing aircraft, industrial process control, active suspension system, fuzzy gain scheduling, PID control, and adaptive neuro control. Numerical coverage with MATLAB® is integrated, and numerous examples and exercises are included for each chapter. Associated MATLAB® code will be made available.

This is the biggest, most comprehensive, and most prestigious compilation of articles on control systems imaginable. Every aspect of control is expertly covered, from the mathematical foundations to applications in robot and manipulator control. Never before has such a massive amount of authoritative, detailed, accurate, and well-organized information been available in a single volume. Absolutely everyone working in any aspect of systems and controls must have this book!

With the science of robotics undergoing a major transformation just now, Springer's new, authoritative handbook on the subject couldn't have come at a better time. Having broken free from its origins in industry, robotics has been rapidly expanding into the challenging terrain of unstructured environments. Unlike other handbooks that focus on industrial applications, the Springer Handbook of Robotics incorporates these new developments. Just like all Springer Handbooks, it is utterly comprehensive, edited by internationally renowned experts, and replete with contributions from leading researchers from around the world. The handbook is an ideal resource for robotics experts but also for people new to this expanding field.

With respect to the future urban mobility, modern electrical bicycles, advanced motorcycles and innovative two-wheeled vehicles are arresting enormous amount of attention. Especially, model-based control and optimal trajectory planning for such vehicles are important to the research and development of the future. Therefore, a reliable and yet usable vehicle model as well as a systematic approach to motion control for two-wheeled vehicles are essential, to which this work makes a contribution. Currently available two-wheeled vehicle models are mostly either too complex to be used for a systematic control synthesis, or too simple such that the physical behaviour of the vehicle is no more represented. In this thesis, a unifying approach to modelling and control for autonomous two-wheeled vehicles is presented. The resulting model is generally valid and physically detailed enough to represent the characteristic dynamical behaviour such as the self-stability. At the same time, it is suited to a systematic control synthesis. Furthermore, the systematic extenddability, for instance by a rider, is demonstrated. The model is validated by simulations and by comparison to well-known models from the literature. The proposed vehicle model is derived in the Lagrangian and Hamiltonian framework and used for model-based optimal trajectory planning. Furthermore, a passivity-based trajectory tracking controller is designed based on the resulting port-Hamiltonian system using the so-called generalised canonical transformations. Such a controller is physically interpretable and robust against parameter uncertainties. To this end, existing approaches of passivity-based controller design are extended and adjusted for two-wheeled vehicles. Finally, a prototype two-wheeled vehicle is introduced which is used for experimental validation of the model and to demonstrate motion control algorithms for autonomous two-wheeled vehicles. Highlighting the control of networked robotic systems, this book synthesizes a unified passivity-based approach to an emerging cross-disciplinary subject. Thanks to this unified approach, readers can access various state-of-the-art research fields by studying only the background foundations associated with passivity. In addition to the theoretical results and techniques, the authors provide experimental case studies on testbeds of robotic systems including networked haptic devices, visual robotic systems, robotic network systems and visual sensor network systems. The text begins with an introduction to passivity and passivity-based control together with the other foundations needed in this book. The main body of the book consists of three parts. The first examines how passivity can be utilized for bilateral teleoperation and demonstrates the inherent robustness of the passivity-based controller against communication delays. The second part emphasizes passivity's usefulness for visual feedback control and estimation. Convergence is rigorously proved even when other passive components are interconnected. The passivity approach is also differentiated from other methodologies. The third part presents the unified passivity-based control-design methodology for multi-agent systems. This scheme is shown to be either immediately applicable or easily extendable to the solution of various motion coordination problems including 3-D attitude/pose synchronization, flocking control and cooperative motion estimation. Academic researchers and practitioners working in systems and control and/or robotics will appreciate the potential of the elegant and novel approach to the control of networked robots presented here. The limited background required and the case-study work described also make the text appropriate for and, it is hoped, inspiring to students.