Advanced Theory of Constraint and Motion Analysis for Robot Mechanisms provides a complete analytical approach to the invention of new robot mechanisms and the analysis of existing designs. It offers a unified mathematical description of the kinematic and geometric constraints of mechanisms.

Beginning with a high-level introduction to mechanisms and kinematic analysis, the book moves on to present a new analytical theory of terminal constraints for use in the development of spatial mechanisms and structures. It clearly describes the application of screw theory to kinematic problems and provides tools that students, engineers, and researchers can use for investigation of critical factors such as workspace, dexterity, and singularity. Combines constraint and free motion analysis and design, offering a new approach to robot mechanism innovation and improvement. Clearly describes the use of screw theory in robot kinematic analysis, allowing for concise representation of motion and static forces when compared to conventional analysis methods.

Includes worked examples to translate theory into practice and demonstrate the application of new analytical methods to critical robotics problems.

Introduction to Autonomous Robots

"Presents a solid framework for understanding existing work and planning future research."--Cover.

Robots in Education

This open access book bridges the gap between playing with robots in school and studying robotics at the undergraduate and graduate levels to prepare for careers in industry and research. Robotic algorithms are presented formally, but using only mathematics known by high-school and first-year college students, such as calculus, matrices, and probability. Concepts and algorithms are explained through detailed diagrams and calculations. Elements of Robotics presents an overview of different types of robots and the components used to build robots, but focuses on robotic algorithms: simple robotic algorithms are presented, with an emphasis on algorithms and the underlying mathematics.
A Mathematical Introduction to Robotic Manipulation

Microbiorobotics is a new engineering discipline that inherently involves a multidisciplinary approach (mechanical engineering, cellular biology, mathematical modeling, control systems, synthetic biology, etc). Building robotics system in the micro scale is an engineering task that has resulted in many important applications, ranging from micromanufacturing techniques to cellular manipulation. However, it is also a very challenging engineering task. One of the reasons is because many engineering ideas and principles that are used in larger scales do not scale well to the micro-scale. For example, locomotion principles in a fluid do not function in the same way, and the use of rotational motors is impractical because of the difficulty of building of the required components. Microrobotics is an area that is acknowledged to have massive potential in applications from medicine to manufacturing. This book introduces an inter-disciplinary readership to the toolkit that micro-organisms offer to micro-engineering. The design of robots, sensors and actuators faces a range of technology challenges at the micro-scale. This book shows how biological techniques and materials can be used to meet these challenges. World-class multidisciplinary editors and contributors leverage insights from engineering, mathematical modeling and the life sciences – creating a novel toolkit for microrobotics.

Screw Theory in Robotics

This book provides readers with basic concepts and design theories for space robots and presents essential methodologies for implementing space robot engineering by introducing several concrete projects as illustrative examples. Readers will gain a comprehensive understanding of professional theories in the field of space robots, and will find an initial introduction to the engineering processes involved in developing space robots. Rapid advances in technologies such as the Internet of Things, Cloud Computing, and Artificial Intelligence have also produced profound changes in space robots. With the continuous expansion of human exploration of the universe, it is imperative for space robots to be capable of sharing knowledge, working collaboratively, and becoming more and more intelligent so as to optimize the utilization of space resources. For on-orbit robots that perform service tasks such as spacecraft assembly and maintenance, as well as exploration robots that carry out research tasks on planetary surfaces, the rational integration into a network system can greatly improve their capabilities in connection with executing outer space tasks, such as information gathering and utilization, independent decision-making and planning, risk avoidance, and reliability, while also significantly reducing resource consumption for the system as a whole.
A comprehensive exploration of the control schemes of human-robot interactions. In *Human-Robot Interaction Control Using Reinforcement Learning*, an expert team of authors delivers a concise overview of human-robot interaction control schemes and insightful presentations of novel, model-free and reinforcement learning controllers. The book begins with a brief introduction to state-of-the-art human-robot interaction control and reinforcement learning before moving on to describe the typical environment model. The authors also describe some of the most famous identification techniques for parameter estimation. *Human-Robot Interaction Control Using Reinforcement Learning* offers rigorous mathematical treatments and demonstrations that facilitate the understanding of control schemes and algorithms. It also describes stability and convergence analysis of human-robot interaction control and reinforcement learning based control. The authors also discuss advanced and cutting-edge topics, like inverse and velocity kinematics solutions, H2 neural control, and likely upcoming developments in the field of robotics. Readers will also enjoy: a thorough introduction to model-based human-robot interaction control, comprehensive explorations of model-free human-robot interaction control and human-in-the-loop control using Euler angles, practical discussions of reinforcement learning for robot position and force control, as well as continuous time reinforcement learning for robot force control, in-depth examinations of robot control in worst-case uncertainty using reinforcement learning, and the control of redundant robots using multi-agent reinforcement learning. Perfect for senior undergraduate and graduate students, academic researchers, and industrial practitioners studying and working in the fields of robotics, learning control systems, neural networks, and computational intelligence, *Human-Robot Interaction Control Using Reinforcement Learning* is also an indispensable resource for students and professionals studying reinforcement learning.

**Advanced Dynamics Modeling, Duality and Control of Robotic Systems**

Introduces the basic concepts of robot manipulation—the fundamental kinematic and dynamic analysis of manipulator arms, and the key techniques for trajectory control and compliant motion control. Material is supported with abundant examples adapted from successful industrial practice or advanced research topics. Includes carefully devised conceptual diagrams, discussion of current research topics with references to the latest publications, and end-of-book problem sets. Appendixes. Bibliography.

**Robot Analysis and Control**

An introduction to the techniques and algorithms of the newest field in robotics. Probabilistic robotics is a new and growing area in robotics, concerned with perception and control in the face of uncertainty. Building on the field of mathematical statistics, probabilistic robotics endows robots with a new level of robustness in real-world situations. This book introduces the reader to a wealth of techniques and algorithms in the field. All algorithms are based on a single overarching mathematical foundation. Each chapter provides example implementations in pseudo code, detailed mathematical derivations, discussions from a practitioner's perspective, and extensive lists of exercises and class projects. The book's Web site, www.probabilistic-robotics.org, has additional material. The book is relevant for anyone involved in robotic software development and scientific research. It will also be of interest to applied statisticians and engineers dealing with real-world sensor data.

**A Mathematical Introduction to Robotic Manipulation**

* Provides an elegant introduction to the geometric concepts that are important to applications in robotics
* Includes significant state-of-the-art material that reflects important advances, connecting robotics back to mathematical fundamentals in group theory and geometry
* An invaluable reference that serves as a
Introduction to Humanoid Robotics

This self-contained introduction to practical robot kinematics and dynamics includes a comprehensive treatment of robot control. It provides background material on terminology and linear transformations, followed by coverage of kinematics and inverse kinematics, dynamics, manipulator control, robust control, force control, use of feedback in nonlinear systems, and adaptive control. Each topic is supported by examples of specific applications. Derivations and proofs are included in many cases. The book includes many worked examples, examples illustrating all aspects of the theory, and problems.

Distributed Control of Robotic Networks

Screw theory is an effective and efficient method used in robotics applications. This book demonstrates how to implement screw theory, explaining the key fundamentals and real-world applications using a practical and visual approach. An essential tool for those involved in the development of robotics implementations, the book uses case studies to analyze mechatronics. Screw theory offers a significant opportunity to interpret mechanics at a high level, facilitating contemporary geometric techniques in solving common robotics issues. Using these solutions results in an optimized performance in comparison to algebraic and numerical options. Demonstrating techniques such as six-dimensional (6D) vector notation and the Product of Exponentials (POE), the use of screw theory notation reduces the need for complex algebra, which results in simpler code, which is easier to write, comprehend, and debug. The book provides exercises and simulations to demonstrate this with new formulas and algorithms presented to aid the reader in accelerating their learning. By walking the user through the fundamentals of screw theory, and by providing a complete set of examples for the most common robot manipulator architecture, the book delivers an excellent foundation through which to comprehend screw theory developments. The visual approach of the book means it can be used as a self-learning tool for professionals alongside students. It will be of interest to those studying robotics, mechanics, mechanical engineering, and electrical engineering.

Underwater Robots

A modern and unified treatment of the mechanics, planning, and control of robots, suitable for a first course in robotics.

A Mathematical Introduction to Robotic Manipulation

Introduction -- Math fundamentals -- Numerical methods -- Dynamics -- Optimal estimation -- State estimation -- Control -- Perception -- Localization and mapping -- Motion planning

Computational Principles of Mobile Robotics

As the capability and utility of robots has increased dramatically with new technology, robotic systems can perform tasks that are physically dangerous for humans. This book discusses the computational principles of mobile robotics, covering kinematics, planning, and control. It provides a comprehensive overview of the field and is suitable for use as a textbook for courses in robotics, computer science, and mechanical engineering. The book includes numerous examples and exercises to help readers develop their understanding of the material.
humans, repetitive in nature, or require increased accuracy, precision, and sterile conditions to radically minimize human error. The Robotics and Automation Handbook addresses the major aspects of designing, fabricating, and enabling robotic systems and their various applications. It presents kinetic and dynamic methods for analyzing robotic systems, considering factors such as force and torque. From these analyses, the book develops several controls approaches, including servo actuation, hybrid control, and trajectory planning. Design aspects include determining specifications for a robot, determining its configuration, and utilizing sensors and actuators. The featured applications focus on how the specific difficulties are overcome in the development of the robotic system. With the ability to increase human safety and precision in applications ranging from handling hazardous materials and exploring extreme environments to manufacturing and medicine, the uses for robots are growing steadily. The Robotics and Automation Handbook provides a solid foundation for engineers and scientists interested in designing, fabricating, or utilizing robotic systems.

Modern Robotics

This book deals with the state of the art in underwater robotics experiments of dynamic control of an underwater vehicle. The author presents experimental results on motion control and fault tolerance to thrusters' faults with the autonomous vehicle ODIN. This second substantially improved and expanded edition new features are presented dealing with fault-tolerant control and coordinated control of autonomous underwater vehicles.

Elements of Robotics

Computer simulation of high-cost applications, especially those involving massive amounts of robotic equipment, is much more efficient than traditional laboratory means. This new textbook presents procedures that make an important contribution to the effective use of automated manufacturing. It also uses a unique combination of computer and robot skills to achieve solutions to the problems discussed throughout the text. Methods of utilizing existing simulation software are emphasized since this enables students to create workable robot designs through a better understanding of basic simulation techniques. Robotic Simulation is designed for introductory courses in simulation. For short courses or seminars, the chapters dealing with hardware-dependent applications can easily be omitted without interfering with the continuity of the text. The book’s computerized simulation approach to robotics is an indispensable supplement to the normal methods taught in a course on robots.

Robot Vision

This book provides readers with a solid set of diversified and essential tools for the theoretical modeling and control of complex robotic systems, as well as for digital human modeling and realistic motion generation. Following a comprehensive introduction to the fundamentals of robotic kinematics, dynamics and control systems design, the author extends robotic modeling procedures and motion algorithms to a much higher-dimensional, larger scale and more sophisticated research area, namely digital human modeling. Most of the methods are illustrated by MATLAB™ codes and sample graphical visualizations, offering a unique closed loop between conceptual understanding and visualization. Readers are guided through practicing and creating 3D graphics for robot arms as well as digital human models in MATLAB™, and through driving them for real-time animation. This work is intended to serve as a robotics textbook with an extension to digital human modeling for senior undergraduate and graduate engineering students. At the same time, it represents a comprehensive reference guide for all researchers, scientists and professionals eager to learn the fundamentals of robotic systems as well as the basic methods of digital human modeling and motion generation.
A Mathematical Introduction to Robotic Manipulation presents a mathematical formulation of the kinematics, dynamics, and control of robot manipulators. It uses an elegant set of mathematical tools that emphasizes the geometry of robot motion and allows a large class of robotic manipulation problems to be analyzed within a unified framework. The foundation of the book is a derivation of robot kinematics using the product of the exponentials formula. The authors explore the kinematics of open-chain manipulators and multifingered robot hands, present an analysis of the dynamics and control of robot systems, discuss the specification and control of internal forces and internal motions, and address the implications of the nonholonomic nature of rolling contact are addressed, as well. The wealth of information, numerous examples, and exercises make A Mathematical Introduction to Robotic Manipulation valuable as both a reference for robotics researchers and a text for students in advanced robotics courses.

Introduction to Robotics

This comprehensive textbook about robot grasping, readers will discover an integrated look at the major concepts and technical results in robot grasp mechanics. A large body of prior research, including key theories, graphical techniques, and insights on robot hand designs, is organized into a systematic approach. The authors present a unified treatment of the geometric and kinematic aspects of robot grasping, emphasizing the use of Lie groups and algebraic geometry. The book covers a wide range of topics, from the fundamental principles of grasp stability and dexterity to advanced topics such as the design of robot hands and the optimization of grasping forces. Throughout the text, the authors provide numerous examples and exercises to help readers develop a deep understanding of the subject.
A Mathematical Introduction To Robotic Manipulation presents a mathematical formulation of the kinematics, dynamics, and control of robot manipulators. It uses an elegant set of mathematical tools that emphasize the geometry of robot motion and allows a large class of robotic manipulation problems to be analyzed within a unified framework. The foundation of the book is a derivation of robot kinematics using the product of the exponentials formula. The authors explore the kinematics of open-chain manipulators and multifingered robot hands, present an analysis of the dynamics and control of robot systems, discuss the specification and control of internal forces and internal motions, and address the implications of the nonholonomic nature of rolling contact are addressed, as well. The wealth of information, numerous examples, and exercises make A Mathematical Introduction to Robotic Manipulation valuable as both a reference for robotics researchers and a text for students in advanced robotics courses.
A Mathematical Introduction To Robotic Manipulation

Written by two of Europe's leading robotics experts, this book provides the tools for a unified approach to the modelling of robotic manipulators, whatever their mechanical structure. No other publication covers the three fundamental issues of robotics: modelling, identification and control. It covers the development of various mathematical models required for the control and simulation of robots.

Mobile Robotics

Written for senior level or first year graduate level robotics courses, this text includes material from traditional mechanical engineering, control theoretical material and computer science. It includes coverage of rigid-body transformations and forward and inverse positional kinematics.

A Mathematical Introduction to Robotic Manipulation

Nonholonomic Motion Planning

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.

The Mechanics of Robot Grasping
Nonholonomic Motion Planning grew out of the workshop that took place at the 1991 IEEE International Conference on Robotics and Automation. It consists of contributed chapters representing new developments in this area. Contributors to the book include robotics engineers, nonlinear control experts, differential geometers and applied mathematicians. Nonholonomic Motion Planning is arranged into three chapter groups: Controllability: one of the key mathematical tools needed to study nonholonomic motion. Motion Planning for Mobile Robots: in this section the papers are focused on problems with nonholonomic velocity constraints as well as constraints on the generalized coordinates. Falling Cats, Space Robots and Gauge Theory: there are numerous connections to be made between symplectic geometry techniques for the study of holonomies in mechanics, gauge theory and control. In this section these connections are discussed using the backdrop of examples drawn from space robots and falling cats reorienting themselves.

Mathematics for Machine Learning

The second edition of this book would not have been possible without the comments and suggestions from students, especially those at Columbia University. Many of the new topics introduced here are a direct result of student feedback that helped refine and clarify the material. The intention of this book was to develop material that the author would have liked to have had available as a student. Theory of Applied Robotics: Kinematics, Dynamics, and Control (2nd Edition) explains robotics concepts in detail, concentrating on their practical use. Related theorems and formal proofs are provided, as are real-life applications. The second edition includes updated and expanded exercise sets and problems. New coverage includes: components and mechanisms of a robotic system with actuators, sensors and controllers, along with updated and expanded material on kinematics. New coverage is also provided in sensing and control including position sensors, speed sensors and acceleration sensors. Students, researchers, and practicing engineers alike will appreciate this user-friendly presentation of a wealth of robotics topics, most notably orientation, velocity, and forward kinematics.

Modeling, Identification and Control of Robots

Robots in Education is an accessible introduction to the use of robotics in formal learning, encompassing pedagogical and psychological theories as well as implementation in curricula. Today, a variety of communities across education are increasingly using robots as general classroom tutors, tools in STEM projects, and subjects of study. This volume explores how the unique physical and social-interactive capabilities of educational robots can generate bonds with students while freeing instructors to focus on their individualized approaches to teaching and learning. Authored by a uniquely interdisciplinary team of scholars, the book covers the basics of robotics and their supporting technologies; attitudes toward and ethical implications of robots in learning; research methods relevant to extending our knowledge of the field; and more.

Probabilistic Robotics

This book provides an introduction to Swarm Robotics, which is the application of methods from swarm intelligence to robotics. It goes on to present methods that allow readers to understand how to design large-scale robot systems by going through many example scenarios on topics such as aggregation, coordinated motion (flocking), task allocation, self-assembly, collective construction, and environmental monitoring. The author explains the methodology behind building multiple, simple robots and how the complexity emerges from the multiple interactions between these robots such that they
The book is based on the authors' extensive experience in teaching the subject and offers a comprehensive introduction to the mathematics of robotic arm control. It covers topics such as kinematics, dynamics, and control, and is written for students and professionals alike. The book is divided into four parts, each focusing on a different aspect of robotic arm control. The first part covers the mathematical foundations, while the second part delves into the kinematics of robotic arms. The third part focuses on the dynamics of robotic arms, and the fourth part covers control strategies for robotic arms. The book includes numerous exercises and examples to help readers understand the material. It also features contributions from leading experts in the field, making it a valuable resource for anyone interested in robotic arm control.
A Mathematical Introduction to Robotic Manipulation

This book is ideal for students and professionals interested in the mathematical foundations of robotic manipulation. It provides a comprehensive and unified treatment of the mathematical principles that underlie the control and simulation of robotic systems. The authors explore the kinematics, dynamics, and control of robotic systems, covering topics such as open-chain manipulators, multifingered robot hands, and the analysis of robot dynamics and control. The book is suitable for advanced courses in robotics and is a valuable resource for researchers in the field.

Geometrical Methods in Robotics

This book is designed for researchers, engineers, and students involved in humanoid robotics research. It starts with a historical overview of humanoid robotics and then delves into the necessary mathematics and physics, including kinematics of multi-body systems, Zero-Moment Point (ZMP), and body motion. The book covers in-depth discussions on biped walking control and other topics related to the generation of whole-body motion. It also presents Matlab codes for testing algorithms and enhancing the reader's understanding.

An Introduction to Theoretical Kinematics

This research book is aimed at providing detailed fundamental reviews and preparations necessary for developing advanced dynamics modeling and control strategies for various types of robotic systems. It specifically addresses the uniqueness issue of representing orientation or rotation and proposes a novel isometric embedding approach. The book includes advanced topics such as the duality principle in robot kinematics, statics, and dynamics, and is intended to serve as a research reference for a diverse audience.

Geometric Fundamentals of Robotics

This book introduces concepts in mobile, autonomous robotics for 3rd-4th year students in Computer Science or a related field. It covers principles of robot motion, forward and inverse kinematics, robotic arms, simple wheeled platforms, perception, error propagation, localization, and simultaneous localization and mapping. The book is open source, open to contributions, and released under a creative common license.

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