Control Of Robot Manipulators In Joint Space Advanced Textbooks In Control And Signal Processing

Homogeneous transformations; Kinematic equations; Solving kinematic equations; Differential relationships; Motion trajectories; Dynamics; Control; Static forces; Compliance; Programming.

A study of the latest research results in the theory of robot control, structured so as to echo the gradual development of robot control over the last fifteen years. In three major parts, the editors deal with the modelling and control of rigid and flexible robot manipulators and mobile robots. Most of the results on rigid robot manipulators in part I are now well established, while for flexible manipulators in part II, some problems still remain unresolved. Part III deals with the control of mobile robots, a challenging area for future research. The whole is rounded off with an appendix reviewing basic definitions and the mathematical background for control theory. The particular combination of topics makes this an invaluable source of information for both graduate students and researchers.

This dissertation, "Adaptive Motion and Force Control of Robot Manipulators With Uncertainties" by ???, Heung-yeung, Shum, was obtained from The University of Hong Kong (Pokfulam, Hong Kong) and is being sold pursuant to Creative Commons: Attribution 3.0 Hong Kong License. The content of this dissertation has not been altered in any way. We have altered the formatting in order to facilitate the ease of printing and reading of the dissertation. All rights not granted by the above license are retained by the author. DOI: 10.5353/th_b3120997 Subjects: Uncertainty (Information theory) Manipulators (Mechanism) - Automatic control Robots, Industrial Adaptive control systems

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.
In this book we have grouped contributions in 28 chapters from several authors all around the world on the several aspects and challenges of research and applications of robots with the aim to show the recent advances and problems that still need to be considered for future improvements of robot success in worldwide frames. Each chapter addresses a specific area of modeling, design, and application of robots but with an eye to give an integrated view of what make a robot a unique modern system for many different uses and future potential applications. Main attention has been focused on design issues as thought challenging for improving capabilities and further possibilities of robots for new and old applications, as seen from today technologies and research programs. Thus, great attention has been addressed to control aspects that are strongly evolving also as function of the improvements in robot modeling, sensors, servo-power systems, and informatics. But even other aspects are considered as of fundamental challenge both in design and use of robots with improved performance and capabilities, like for example kinematic design, dynamics, vision integration.
The robotic mechanism and its controller make a complete system. As the robotic mechanism is reconfigured, the control system has to be adapted accordingly. The need for the reconfiguration usually

arises from the changing functional requirements. This book will focus on the adaptive control of robotic manipulators to address the changed conditions. The aim of the book is to summarise and introduce the state-of-the-art technologies in the field of adaptive control of robotic manipulators in order to improve the methodologies on the adaptive control of robotic manipulators. Advances made in the past decades are described in the book, including adaptive control theories and design, and application of adaptive control to robotic manipulators.

This book presents recent advances in robot control theory on task space sensory feedback control of robot manipulators. By using sensory feedback information, the robot control systems are robust to various uncertainties in modelling and calibration errors of the sensors. Several sensory task space control methods that do not require exact knowledge of either kinematics or dynamics of robots, are presented. Some useful methods such as approximate Jacobian control, adaptive Jacobian control, region control and multiple task space regional feedback are included. These formulations and methods give robots a high degree of flexibility in dealing with unforeseen changes and uncertainties in its kinematics and dynamics, which is similar to human reaching movements and tool manipulation. It also leads to the solution of several long-standing problems and open issues in robot control, such as force control with constraint uncertainty, control of multi-fingered robot hand with uncertain contact points, singularity issue of Jacobian matrix, global task-space control, which are also presented in this book. The target audience for this book includes scientists, engineers and practitioners involved in the field of robot control theory.

Robot Manipulator Control offers a complete survey of control systems for serial-link robot arms and acknowledges how robotic device performance hinges upon a well-developed control system. Containing over 750 essential equations, this thoroughly up-to-date Second Edition, the book explicates theoretical and mathematical requisites for controls design and summarizes current techniques in computer simulation and implementation of controllers. It also addresses procedures and issues in computed-torque, robust, adaptive, neural network, and force control. New chapters relay practical information on commercial robot manipulators and devices and cutting-edge methods in neural network control.

This book treats visual feedback control of mechanical systems, mostly robot manipulators. It not only deals with image processing techniques and robot control schemes but also covers the latest investigation of the design of the visual servo mechanism based on modern linear and nonlinear control theory, the adaptive control scheme, fuzzy logic, and neural networks. New concepts for utilizing visual sensory information for real-time manipulator control are derived and the performances are evaluated through simulations and/or experiments.The contributors to this book are robotics specialists from all over the world. The book gives a practical perspective on visual servoing to researchers, engineers, and students working in this area.

Control Dynamics of Robotic Manipulators deals with both theory and mechanics of control and systems dynamics used in robotic movements. The book discusses mechanical models of robot manipulators in relation to modular RP-unit manipulators, multiple mechanical system (Cartesian Model), or generalized coordinates (Lagrangian Model). The text also describes equations used to determine the force characteristics, energy, and power required in manipulators. For example, damping forces dissipate energy caused by dry friction or viscous damping at mechanical joints due to slips and sheer effects on surfaces. Other examples are oil, water, and air resistance in the environment of the manipulator, as well as damping in links caused by microscopic interface effects. Demands for high-speed and high-accuracy in manipulators require sturdiness in control against variations in the system parameter. The book cites a situation where the manipulator works in a "hot cell" and must be controlled remotely. The text also tackles the avoidance of obstacles by nonvisual means by referring to the works of Lozano, Perez and Wesley, and of Reibert and Horn. The text is useful for students of civil, structural, and mechanical engineering. It will also profit technicians of automatic, telecontrol, and designers of industrial machinery.

Robot interaction control is one of the most challenging targets for industrial robotics. While it would provide the robotic systems with a high degree of autonomy, its effectiveness is limited by the complexity of this problem and by the necessity of special sensors (six-dof force sensors). On the other hand, the control methodologies to be adopted for addressing this problem can be considered mature and well-assessed. All the known interaction control strategies (e.g. impedance, direct force control) are tackled and reshuffled in a geometrically consistent way for simplification of the task specification and enhancement of the execution performance. This book represents the first step towards the application of theoretical results at an industrial level; in fact each proposed control algorithm is experimentally tested here on an industrial robotic setup.

Based on the successful Modelling and Control of Robot Manipulators by Sciavicco and Siciliano (Springer, 2000), Robotics provides the basic know-

how on the foundations of robotics: modelling, planning and control. It has been expanded to include coverage of mobile robots, visual control and motion planning. A variety of problems is raised throughout, and the proper tools to find engineering-oriented solutions are introduced and explained. The text includes coverage of fundamental topics like kinematics, and trajectory planning and related technological aspects including actuators and sensors. To impart practical skill, examples and case studies are carefully worked out and interwoven through the text, with frequent resort to simulation. In addition, end-of-chapter exercises are proposed, and the book is accompanied by an electronic solutions manual containing the MATLAB® code for computer problems; this is available free of charge to those adopting this volume as a textbook for courses.
Introduces a revolutionary, quadratic-programming based approach to solving long-standing problems in motion planning and control of redundant manipulators This book describes a novel quadratic programming approach to solving redundancy resolutions problems with redundant manipulators. Known as ``QP-unified motion planning and control of redundant manipulators'' theory, it systematically solves difficult optimization problems of inequality-constrained motion planning and control of redundant manipulators that have plagued robotics engineers and systems designers for more than a

quarter century. An example of redundancy resolution could involve a robotic limb with six joints, or degrees of freedom (DOFs), with which to position an object. As only five numbers are required to specify the position and orientation of the object, the robot can move with one remaining DOF through practically infinite poses while performing a specified task. In this case redundancy resolution refers to the process of choosing an optimal pose from among that infinite set. A critical issue in robotic systems control, the redundancy resolution problem has been widely studied for decades, and numerous solutions have been proposed. This book investigates various approaches to motion planning and control of redundant robot manipulators and describes the most successful strategy thus far developed for resolving redundancy resolution problems. Provides a fully connected, systematic, methodological, consecutive, and easy approach to solving redundancy resolution problems Describes a new approach to the time-varying Jacobian matrix pseudoinversion, applied to the redundant-manipulator kinematic control Introduces The QP-based unification of robots' redundancy resolution Illustrates the effectiveness of the methods presented using a large number of computer simulation results based on PUMA560, PA10, and planar robot manipulators Provides technical details for all schemes and solvers presented, for readers to adopt and customize them for specific industrial applications Robot Manipulator Redundancy Resolution is must-reading for advanced undergraduates and graduate students of robotics, mechatronics, mechanical engineering, tracking control, neural dynamics/neural networks, numerical algorithms, computation and optimization, simulation and modelling, analog, and digital circuits. It is also a valuable working resource for practicing robotics engineers and systems designers and industrial researchers.

This book presents the most recent research results on modeling andcontrol of robot manipulators. Chapter 1 gives unified tools to derive direct andinverse geometric, kinematic and dynamic models of serial robotsand addresses the issue of identification of the geometric anddynamic parameters of these models. Chapter 2 describes the main features of serial robots,the different architectures and the methods used to obtain directand inverse geometric, kinematic and dynamic models, paying specialattention to singularity analysis. Chapter 3 introduces global and local tools forperformance analysis of serial robots. Chapter 4 presents an original optimization techniquefor point-to-point trajectory generation accounting for robotdynamics. Chapter 5 presents standard control techniques in thejoint space and task space for free motion (PID, computed torque,adaptive dynamic

control and variable structure control) andconstrained motion (compliant force-position control). In Chapter 6, the concept of vision-based control isdeveloped and Chapter 7 is devoted to specific issue ofrobots with flexible links. Efficient recursive Newton-Euleralgorithms for both inverse and direct modeling are presented, aswell as control methods ensuring position setting and vibrationdamping.
Fundamental and technological topics are blended uniquely and developed clearly in nine chapters with a gradually increasing level of complexity. A wide variety of relevant problems is raised throughout, and the proper tools to find engineering-oriented solutions are introduced and explained, step by step. Fundamental coverage includes: Kinematics; Statics and dynamics of manipulators; Trajectory planning and motion control in free space. Technological aspects include: Actuators; Sensors; Hardware/software control architectures; Industrial robot-control algorithms. Furthermore, established research results involving description of end-effector orientation, closed kinematic chains, kinematic redundancy and singularities, dynamic parameter identification, robust and adaptive control and force/motion control are provided. To provide readers with a homogeneous background, three appendices are included on: Linear algebra; Rigid-body mechanics; Feedback control. To acquire

practical skill, more than 50 examples and case studies are carefully worked out and interwoven through the text, with frequent resort to simulation. In addition, more than 80 end-of-chapter exercises are proposed, and the book is accompanied by a solutions manual containing the MATLAB code for computer problems; this is available from the publisher free of charge to those adopting this work as a textbook for courses.

This monograph provides a comprehensive and thorough treatment of the problem of controlling a redundant robot manipulator. It presents the latest research from the field with a good balance between theory and practice. All theoretical developments are verified both via simulation and experimental work on an actual prototype redundant robot manipulator. This book is the first text aimed at graduate students and researchers working in the area of redundant manipulators giving a comprehensive coverage of control of redundant robot manipulators from the viewpoint of theory and experimentation.

This book reports recent and new developments in modeling, simulation and control of flexible robot manipulators. The material is presented in four distinct components: a range of modeling approaches including classical techniques based on the Lagrange equation formulation, parametric approaches based on linear input/output models using system identification techniques and neuro-modeling approaches; numerical modeling/simulation techniques for dynamic characterization of flexible manipulators using the finite difference, finite element, symbolic manipulation and customized software techniques; a range of open-loop and closed-loop control techniques based on classical and modern intelligent control methods including soft-computing and smart structures for flexible manipulators; and software environments for analysis, design, simulation and control of flexible manipulators.

Robot manipulators are developing more in the direction of industrial robots than of human workers. Recently, the applications of robot manipulators are spreading their focus, for example Da Vinci as a medical robot, ASIMO as a humanoid robot and so on. There are many research topics within the field of robot manipulators, e.g. motion planning, cooperation with a human, and fusion with external sensors like vision, haptic and force, etc. Moreover, these include both technical problems in the industry and theoretical problems in the academic fields. This book is a collection of papers presenting the latest research issues from around the world.

This dissertation, "Model-based Variable-structure Control of Robot Manipulators in Joint Space and in Cartesian Space" by ???, Po-lun, Law, was obtained from The University of Hong Kong (Pokfulam, Hong Kong) and is being sold pursuant to Creative Commons: Attribution 3.0 Hong Kong License. The content of this dissertation has not been altered in any way. We have altered the formatting in order to facilitate the ease of printing and reading of the dissertation. All rights not granted by the above license are retained by the author. DOI: 10.5353/th_b3121246 Subjects: Robotics Manipulators (Mechanism) - Automatic control

Modelling and Control of Robot ManipulatorsSpringer Science & Business Media

Flexible robotic manipulators pose various challenges in research as compared to rigid robotic manipulators, ranging from system design, structural optimization, and construction to modeling, sensing, and control. Although significant progress has been made in many aspects over the last one-and-a-half decades, many issues are not resolved yet, and simple, effective, and reliable controls of flexible manipulators still remain an open quest. Clearly, further efforts and results in this area will contribute significantly to robotics (particularly automation) as well as its application and education in general control engineering. To accelerate this process, the leading experts in this important area present in this book the state of the art in advanced studies of the design, modeling, control and applications of flexible manipulators. Sample Chapter(s). Chapter 1: Flexible-link Manipulators: Modeling, Nonlinear Control and Observer (235 KB). Contents: Flexible-Link Manipulators: Modeling, Nonlinear Control and Observer (M A Arteaga & B Siciliano); Energy-Based Control of Flexible Link Robots (S S Ge); Trajectory Planning and Compliant Control for Two Manipulators to Deform Flexible Materials (O Al-Jarrah et al.); Force Control of Flexible Manipulators (F Matsuno); Experimental Study on the Control of Flexible Link Robots (D Wang); Sensor Output Feedback Control of Flexible Robot Arms (Z-H Luo); On GA Based Robust Control of Flexible Manipulators (Z-Q Xiao & L-L Cui); Analysis of Poles and Zeros for Tapered Link Designs (D L Girvin & W J Book); Optimum Shape Design of Flexible Manipulators with Tip Loads (J L Russell & Y-Q Gao); Mechatronic Design of Flexible Manipulators

(P-X Zhou & Z-Q Xiao); A Comprehensive Study of Dynamic Behaviors of Flexible Robotic Links: Modeling and Analysis (Y-Q Gao & F-Y Wang). Readership: Researchers, lecturers and graduate students in robotics & automated systems, electrical & electronic engineering, and industrial engineering Repetitive Motion Planning and Control of Redundant Robot Manipulators presents four typical motion planning schemes based on optimization techniques, including the fundamental RMP scheme and its extensions. These schemes are unified as quadratic programs (QPs), which are solved by neural networks or numerical algorithms. The RMP schemes are demonstrated effectively by the simulation results based on various robotic models; the experiments applying the fundamental RMP scheme to a physical robot manipulator are also presented. As the schemes and the corresponding solvers presented in the book have solved the non-repetitive motion problems existing in redundant robot manipulators, it is of particular use in applying theoretical research based on the quadratic program for redundant robot manipulators in industrial situations. This book will be a valuable reference work for engineers, researchers, advanced undergraduate and graduate students in robotics fields. Yunong Zhang is a professor at The School of Information Science and Technology, Sun Yat-sen University, Guangzhou, China; Zhijun Zhang is a research fellow working at the same institute. Tutors can design entry-level courses in robotics with a strong orientation to the fundamental discipline of manipulator control pdf solutions manual Overheads will save a great deal of time with class preparation and will give students a low-effort basis for more detailed class notes Courses for senior undergraduates can be designed around Parts I – III; these can be augmented for masters courses using Part IV

Foundations of Robotics presents the fundamental concepts and methodologies for the analysis, design, and control of robot manipulators. It explains the physical meaning of the concepts and equations used, and it provides, in an intuitively clear way, the necessary background in kinetics, linear algebra, and control theory. Illustrative examples appear throughout. The author begins by discussing typical robot manipulator mechanisms and their controllers. He then devotes three chapters to the analysis of robot manipulator mechanisms. He covers the kinematics of robot manipulators, describing the motion of manipulator links and objects related to manipulation. A chapter on dynamics includes the derivation of the dynamic equations of motion, their use for control and simulation and the identification of inertial parameters. The final chapter develops the concept of manipulability. The second half focuses on the control of robot manipulators. Various position-control algorithms that guide the manipulator's end effector along a desired trajectory are described Two typical methods used to control the contact force between the end effector and its environments are detailed For manipulators with redundant degrees of freedom, a technique to develop control algorithms for active utilization of the redundancy is described. Appendixes give compact reviews of the function atan2, pseudo inverses, singular-value decomposition, and Lyapunov stability theory. Tsuneo Yoshikawa teaches in the Division of Applied Systems Science in Kyoto University's Faculty of Engineering.

The goal of this study is to design a controller to reject the disturbances caused by sensor noise and unmodeled effects during hybrid adaptive force and motion control of robot manipulators in constrained motion. A continuous robust integral of the sign of the error (RISE) feedback term is incorporated with adaptive force and motion control to yield asymptotic tracking results in the presence of disturbances and unknown system parameters and dry contact surface friction coefficient. The main reason to use the RISE method is that it can enhance disturbance rejection capabilities. It is assumed that the system parameters of the robot manipulator and the dry friction coefficient of contact surface are unknown. These unknown parameters can be updated by the adaptive update law. The suggested controller can guarantee semi-global asymptotic motion and force tracking results which are supported through Lyapunov-based stability analysis under the condition that the position and velocity of end-effector and the normal contact force between end-effector and contact surface are measurable. The contact surface of the environment is modeled by the set of m rigid and mutually independent hypersurfaces. The dynamic model of constrained robot manipulators is developed through an Euler-Lagrange formulation. Two degree of freedom (DOF) robot manipulator simulation results are given to illustrate the efficacy of the suggested controller.