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DAPHNE JORDON

Design and Development of a Precision Packing Stage and Master Control System for an Automated Vial Packaging Machine CRC Press

Since they entered our world around the middle of the 20th century, the application of mechatronics has enhanced our lives with functionality based on the integration of electronics, control systems and electric drives. This book deals with the special class of mechatronics that has enabled the exceptional levels of accuracy and speed of high-tech equipment applied in the semiconductor industry, realising the continuous shrink in detailing of micro-electronics and MEMS. As well as the more frequently presented standard subjects of dynamics, motion control, electronics and electromechanics, this book includes an overview of systems engineering, optics and precision measurement systems, in an attempt to establish a connection between these fields under one umbrella. Robert Munnig Schmidt is emeritus professor in Mechatronic System Design at Delft University of Technology with industrial experience at Philips and ASML in research and development of consumer and high-tech systems. He is also director of RMS Acoustics & Mechatronics, doing research and development on active controlled low frequency sound systems. Georg Schitter is professor at the Automation and Control Institute (ACIN) at Vienna University of Technology with a standing track record in research on the control and mechatronic design of extremely fast precision motion systems such as video rate AFM systems. Adrian Rankers is managing partner of Mechatronics Academy, developing and delivering high level courses to the industrial community, based on industrial experience at Philips in the research and development of consumer and high-tech systems. He also teaches Mechatronics at the Eindhoven University of Technology. Jan van Eijk is emeritus professor in Advanced Mechatronics at Delft University of Technology. He is also director of MICE

BV and partner at Mechatronics Academy, acting as industrial R&D advisor and teacher with experience at Philips in the research and development of consumer and high-tech systems.

Introduction to Precision Machine Design and Error Assessment Springer Science & Business Media

Edited by Takashi Yamaguchi, Mitsuo Hirate, and Chee Khiang Pang, with contributions from pioneers known for their ground-breaking work, High-Speed Precision Motion Control discusses high-precision and fast servo controls in hard disk drives (HDDs). The chapter authors describe the control technologies they've developed, most of which have already been successfully applied to mass production of HDDs. As the proposed methodologies have been verified on commercial HDDs at the very least, these advanced control technologies can also be readily applied to precision motion control of other mechatronic systems, e.g., scanners, micro-positioners, photocopiers, atomic force microscopes (AFMs), etc. Each self-contained chapter progresses from concept to technique and presents application examples in automotive, aerospace, aeronautical, and manufacturing engineering. The control technologies are categorized into high-speed servo control, precision control, and environment-friendly control, making it easy to find an appropriate control technology according to their domain of application. The book also makes MATLAB®/SIMULINK® codes for benchmark problems available for download. The control technologies described range from fundamental classical control theories to advanced topics such as multi-rate control. The content contains a healthy balance between materials from the contributor's research works and that in the wider literature. The resulting resource empowers engineers and managers with the knowledge and know-how to make important decisions and policies.

Industrial Motion Control CRC Press
Advances in engineering precision have tracked with technological progress for hundreds of years. Over the last few

decades, precision engineering has been the specific focus of research on an international scale. The outcome of this effort has been the establishment of a broad range of engineering principles and techniques that form the foundation of precision design. Today's precision manufacturing machines and measuring instruments represent highly specialised processes that combine deterministic engineering with metrology. Spanning a broad range of technology applications, precision engineering principles frequently bring together scientific ideas drawn from mechanics, materials, optics, electronics, control, thermo-mechanics, dynamics, and software engineering. This book provides a collection of these principles in a single source. Each topic is presented at a level suitable for both undergraduate students and precision engineers in the field. Also included is a wealth of references and example problems to consolidate ideas, and help guide the interested reader to more advanced literature on specific implementations.

Analysis and Design of a Magnetically-suspended Precision Motion Control Stage Butterworth-Heinemann

Precision motion control is strongly required in many fields, such as precision engineering, micromanufacturing, biotechnology, and nanotechnology. Although great achievements have been made in control engineering, it is still challenging to fulfill the desired performance for precision motion control systems. Substantial works have been presented to reveal an increasing trend to apply optimization approaches in precision engineering to obtain the control system parameters. In this book, we present a result of several years of work in the area of advanced optimization for motion control systems. The book is organized into two parts: Part I focuses on the model-based approaches, and Part II presents the data-based approaches. To illustrate the practical appeal of the proposed optimization techniques, theoretical results are verified with practical examples in each chapter. Industrial problems explored in the book are formulated systematically with necessary analysis of

the control system synthesis. By virtue of the design and implementation nature, this book can be used as a reference for engineers, researchers, and students who want to utilize control theories to solve the practical control problems. As the methodologies have extensive applicability in many control engineering problems, the research results in the field of optimization can be applied to full-fledged industrial processes, filling in the gap between research and application to achieve a technology frontier increment.

Exact Constraint Butterworth-Heinemann

Advances in photolithography are one of the key driving factors in the continuing expansion in capacity and decrease in cost of semiconductors. Extending this trend into the future necessitates the development of next-generation lithography technologies in order to overcome the fundamental challenges of improving critical dimension and overlay control, and lowering the total cost-of-ownership. As feature sizes become smaller and smaller, performance requirements for wafer scanner machines will become more stringent; with regards to motion control, requirements for the wafer stage include sub-nanometer positioning precision under high scan velocities and accelerations. Advanced control algorithms are needed to meet these requirements in the face of disturbances such as vibrations, noise, force ripple and friction, as well as model uncertainty. This dissertation focuses on using the repetitiveness of the stage's motion in the photolithography process to improve control precision. Similar to many manufacturing processes, the step-and-scan motion used to expose a wafer is very repetitive, on a die-to-die and also wafer-to-wafer level. By using data gathered from past runs, the control effort for future runs may be improved, thereby exploiting the repetitiveness of the process to increase control precision. In this research, *iterative learning control* (ILC) and *iterative feedback tuning* (IFT) were applied to reduce tracking error of the wafer stage. In ILC, a feedforward control signal for the system is incrementally adjusted to achieve better tracking performance using error signals from previous runs. ILC is an attractive method for high-precision control because of its simplicity and data-based nature. In this research, ILC algorithm design specifically for attenuating high frequency vibrations is investigated. Through careful design of the ILC update law, fast learning convergence and small final error is achieved. One

drawback of ILC is that a feedforward signal learned through ILC is only applicable to the training trajectory; learning must be restarted when the trajectory is changed. A method is presented for making ILC results applicable to any trajectory within a class of scan trajectories; this is accomplished by using ILC as a training method for feedforward signal patterns. In IFT, controller parameters are fine-tuned incrementally using only data collected in experimental runs. IFT is applied to tune fixed-structure feedforward, feedback, and force-ripple compensator controllers. The performance of IFT is also compared with ILC in the context of iterative methods for designing feedforward control. All results are verified through computer simulations and experiments done on a wafer stage testbed system.

A Cross-coupled ILC Design for Improved Precision Motion Control
CRC Press

Advances in engineering precision have tracked with technological progress for hundreds of years. Over the last few decades, precision engineering has been the specific focus of research on an international scale. The outcome of this effort has been the establishment of a broad range of engineering principles and techniques that form the foundation of precision design. Today's precision manufacturing machines and measuring instruments represent highly specialised processes that combine deterministic engineering with metrology. Spanning a broad range of technology applications, precision engineering principles frequently bring together scientific ideas drawn from mechanics, materials, optics, electronics, control, thermo-mechanics, dynamics, and software engineering. This book provides a collection of these principles in a single source. Each topic is presented at a level suitable for both undergraduate students and precision engineers in the field. Also included is a wealth of references and example problems to consolidate ideas, and help guide the interested reader to more advanced literature on specific implementations.

Design, Modeling and Control of Nanopositioning Systems American Society of Mechanical Engineers
Modeling and Control of Precision Actuators explores new technologies that can ultimately be applied in a myriad of industries. It covers dynamical analysis of precise actuators and strategies of design for various control applications. The book addresses four main schemes: modeling and control of precise actuators; nonlinear control of precise actuators, including

sliding mode control and neural network feedback control; fault detection and fault-tolerant control; and advanced air bearing control. It covers application issues in the modeling and control of precise actuators, providing several interesting case studies for more application-oriented readers. Introduces the driving forces behind precise actuators Describes nonlinear dynamics of precise actuators and their mathematical forms, including hysteresis, creep, friction, and force ripples Presents the control strategies for precise actuators based on Preisach model as well as creep dynamics Develops relay feedback techniques for identifying nonlinearities such as friction and force ripples Discusses a MPC approach based on piecewise affine models which emulate the frictional effects in the precise actuator Covers the concepts of air bearing stages with the corresponding control method Provides a set of schemes suitable for fault detection and accommodation control of mechanical systems Emphasizing design theory and control strategies, the book includes simulation and practical examples for each chapter; covers precise actuators such as piezo motors, coil motors, air bearing motors, and linear motors; discusses integration among different technologies; and includes three case studies in real projects. The book concludes by linking design methods and their applications, emphasizing the key issues involved and how to implement the precision motion control tasks in a practical system. It provides a concise and comprehensive source of the state-of-the-art developments and results for modeling and control of precise actuators.

Modeling and Control of Precision Actuators CRC Press

This book provides the most important steps and concerns in the design of estimation and control algorithms for induction motors. A single notation and modern nonlinear control terminology is used to make the book accessible, although a more theoretical control viewpoint is also given. Focusing on the induction motor with, the concepts of stability and nonlinear control theory given in appendices, this book covers: speed sensorless control; design of adaptive observers and parameter estimators; a discussion of nonlinear adaptive controls containing parameter estimation algorithms; and comparative simulations of different control algorithms. The book sets out basic assumptions, structural properties, modelling, state feedback control and estimation algorithms, then moves to more complex output feedback control algorithms, based on stator current

measurements, and modelling for speed sensorless control. The induction motor exhibits many typical and unavoidable nonlinear features.

Induction Motor Control Design CRC Press
Exact Constraint: Machine Design Using Kinematic Principles gives you a unique and powerful set of rules and techniques to facilitate the design of any type or size of machine. You learn the kinematic design techniques known as constraint pattern analysis. This method, widely used by designers of precision instruments, enables you to visualize the constraints and degrees of freedom of a mechanical connection as patterns of lines in space. By recognizing these line patterns (found in all types of machinery), you will better understand the way a machine will work - or will not work - in an entirely new domain.

Creating Precision Robots IOS Press
The realm of ultra precision mechanisms, for example in controlling motion to small fractions of a micrometer, is encroaching into many fields of technology. This book aims to provide a bridge for those moving from either an engineering or physics background towards the challenges offered by ultraprecision mechanisms. Using case study examples, this book provides a guide to basic techniques and gives technical, analytical and practical information.

Halbach Arrays in Precision Motion Control CRC Press

Motion Control Systems is concerned with design methods that support the never-ending requirements for faster and more accurate control of mechanical motion. The book presents material that is fundamental, yet at the same time discusses the solution of complex problems in motion control systems. Methods presented in the book are based on the authors' original research results. Mathematical complexities are kept to a required minimum so that practicing engineers as well as students with a limited background in control may use the book. It is unique in presenting know-how accumulated through work on very diverse problems into a comprehensive unified approach suitable for application in high demanding, high-tech products. Major issues covered include motion control ranging from simple trajectory tracking and force control, to topics related to haptics, bilateral control with and without delay in measurement and control channels, as well as control of nonredundant and redundant multibody systems. Provides a consistent unified theoretical framework for motion control design Offers graduated increase in

complexity and reinforcement throughout the book Gives detailed explanation of underlying similarities and specifics in motion control Unified treatment of single degree-of-freedom and multibody systems Explains the fundamentals through implementation examples Based on classroom-tested materials and the authors' original research work Written by the leading researchers in sliding mode control (SMC) and disturbance observer (DOB) Accompanying lecture notes for instructors Simulink and MATLAB® codes available for readers to download Motion Control Systems is an ideal textbook for a course on motion control or as a reference for post-graduates and researchers in robotics and mechatronics. Researchers and practicing engineers will also find the techniques helpful in designing mechanical motion systems.

Repetitive and Iterative Learning Control for Power Converter and Precision Motion Control Springer Science & Business Media
Since they entered our world around the middle of the 20th century, the application of mechatronics has enhanced our lives with functionality based on the integration of electronics, control systems and electric drives. This book deals with the special class of mechatronics that has enabled the exceptional levels of accuracy and speed of high-tech equipment applied in the semiconductor industry, realising the continuous shrink in detailing of micro-electronics and MEMS. As well as the more frequently presented standard subjects of dynamics, motion control, electronics and electromechanics, this book includes an overview of systems engineering, optics and precision measurement systems, in an attempt to establish a connection between these fields under one umbrella. Robert Munnig Schmidt is professor in Mechatronic System Design at Delft University of Technology with industrial experience at Philips and ASML in research and development of consumer and high-tech systems. He is also director of RMS Acoustics & Mechatronics, doing research and development on active controlled low frequency sound systems. Georg Schitter is professor at the Automation and Control Institute (ACIN) at Vienna University of Technology with a standing track record in research on the control and mechatronic design of extremely fast precision motion systems such as video rate AFM systems. Adrian Rankers is managing partner of Mechatronics Academy, developing and delivering high level courses to the industrial community, based on industrial experience at Philips in the research and development of consumer and high-tech systems. Jan van Eijk is emeritus professor

in Advanced Mechatronics at Delft University of Technology. He is also director of MICE BV and partner at Mechatronics Academy, acting as industrial R&D advisor and teacher with experience at Philips in the research and development of consumer and high-tech systems.

Fundamentals of Sliding Mode Control Wiley-IEEE Press

Precision manufacturing is a development that has been gathering momentum over the last century and accelerating over the last 25 years in terms of research, development, and application to product innovation. The driving force in this development arises from requirements for much higher performance of products, higher reliability, longer life, lower cost, and miniaturization. This development is widely known as precision engineering and, today, it is generally defined as manufacturing to tolerances which are better than one part in 105. Applications are abundant and can be found in various semiconductor processes (e.g., lithography, wafer probing, inspection), Coordinate Measuring Machines (CMMs) and precision metrology systems (e.g., Scanning Probe Microscopy (SPM)), and robot/machine tools to carry out micro-assembly (e.g., MEMS) and delicate short wavelength laser processes. As an enabling technology for precision engineering, precision instrumentation and measurement, geometrical calibration and compensation, and motion control are directly important issues to be addressed in the overall system design and realization. This book is focused on these aspects of precision engineering. It is a compilation of the major results and publications from a major project which develop a state-of-the-art high-speed, ultra-precision robotic system. A comprehensive and thorough treatment of the subject matter is provided in a manner that is amenable to a broad base of readers, ranging from the academics to the practitioners, by providing detailed experimental verifications of the developed materials.

Introduction to Precision Machine Design and Error Assessment CRC Press

While ultra-precision machines are now achieving sub-nanometer accuracy, unique challenges continue to arise due to their tight specifications. Written to meet the growing needs of mechanical engineers and other professionals to understand these specialized design process issues, Introduction to Precision Machine Design and Error Assessment places

High-Speed Precision Motion Control

CRC Press

The Halbach array was developed for use as an optical element in particle accelerators. Following up on a suggestion from Klaus Halbach, the authors have investigated the utility of such arrays as the permanent magnet structure for synchronous machines in cartesian, polar, and cylindrical geometries. Their work has focused on the design of a novel Halbach array linear motor for use in a magnetic suspension stage for photolithography. This paper presents the details of the motor design and its force and power characteristics.

Optimal Supervisory Control of Automated Manufacturing Systems CRC Press

Covering the complete design cycle of nan positioning systems, this is the first comprehensive text on the topic. The book first introduces concepts associated with nan positioning stages and outlines their application in such tasks as scanning probe microscopy, nanofabrication, data storage, cell surgery and precision optics. Piezoelectric transducers, employed ubiquitously in nan positioning applications are then discussed in detail including practical considerations and constraints on transducer response. The reader is then given an overview of the types of nan positioner before the text turns to the in-depth coverage of mechanical design including flexures, materials, manufacturing techniques, and electronics. This process is illustrated by the example of a high-speed serial-kinematic nan positioner. Position sensors are then catalogued and described and the text then focuses on control. Several forms of control are treated: shunt control, feedback control, force feedback control and feedforward control (including an appreciation of iterative learning control). Performance issues are given importance as are problems limiting that performance such as hysteresis and noise which arise in the treatment of control and are then given chapter-length attention in their own right. The reader also learns about cost functions and other issues involved in command shaping, charge drives and electrical considerations. All concepts are demonstrated experimentally including by direct application to atomic force microscope imaging. *Design, Modeling and Control of Nan positioning Systems* will be of interest to researchers in mechatronics generally and in control applied to atomic force microscopy and other nan positioning applications. Microscope developers and mechanical designers of nan positioning devices will find the text essential reading.

Basics of Precision Engineering Walter

de Gruyter GmbH & Co KG

This book is a comprehensive engineering exploration of all the aspects of precision machine design—both component and system design considerations for precision machines. It addresses both theoretical analysis and practical implementation providing many real-world design case studies as well as numerous examples of existing components and their characteristics. Fast becoming a classic, this book includes examples of analysis techniques, along with the philosophy of the solution method. It explores the physics of errors in machines and how such knowledge can be used to build an error budget for a machine, how error budgets can be used to design more accurate machines.

The Design of High Performance Mechatronics - 3rd Revised Edition IOS Press

Since they entered our world around the middle of the 20th century, the application of mechatronics has enhanced our lives with functionality based on the integration of electronics, control systems and electric drives. This book deals with the special class of mechatronics that has enabled the exceptional levels of accuracy and speed of high-tech equipment applied in the semiconductor industry, realising the continuous shrink in detailing of micro-electronics and MEMS. As well as the more frequently presented standard subjects of dynamics, motion control, electronics and electromechanics, this book includes an overview of systems engineering, optics and precision measurement systems, in an attempt to establish a connection between these fields under one umbrella. Robert Munnig Schmidt is professor in Mechatronic System Design at Delft University of Technology with industrial experience at Philips and ASML in research and development of consumer and high-tech systems. He is also director of RMS Acoustics & Mechatronics, doing research and development on active controlled low frequency sound systems. Georg Schitter is professor at the Automation and Control Institute (ACIN) at Vienna University of Technology with a standing track record in research on the control and mechatronic design of extremely fast precision motion systems such as video rate AFM systems. Adrian Rankers is managing partner of Mechatronics Academy, developing and delivering high level courses to the industrial community, based on industrial experience at Philips in the research and development of consumer and high-tech systems. Jan van Eijk is emeritus professor in Advanced

Mechatronics at Delft University of Technology. He is also director of MICE BV and partner at Mechatronics Academy, acting as industrial R&D advisor and teacher with experience at Philips in the research and development of consumer and high-tech systems.

Control System Design Guide John Wiley & Sons

Precision Motion Systems: Modeling, Control, and Applications presents basic dynamics and the control knowledge needed for the daily challenges of researchers and professionals working in the field. The book explains accurate dynamics and control algorithms, along with experimental validation of precision systems in industrial, medical, airborne and spaceborne applications. By using the proposed experimental designs, readers will be able to make further developments and validations. Presents accurate dynamics and control algorithms in industrial, medical, airborne and spaceborne applications Explains basic dynamics and control knowledge, such as Laplace transformations and stability analysis Teaches how to design, develop and control typical precision systems *Applications in Control* Butterworth-Heinemann

As the capability and utility of robots has increased dramatically with new technology, robotic systems can perform tasks that are physically dangerous for 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.