

Communications and Control Engineering



Thomas Meurer

Control of Higher— Dimensional PDEs

Flatness and Backstepping Designs



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Control Of Higher Dimensional Pdes Flatness And Backstepping Designs Communications And Control Engineering

Stephen Chen



Control Of Higher Dimensional Pdes Flatness And Backstepping Designs Communications And Control Engineering:

Control of Higher-Dimensional PDEs Thomas Meurer, 2012-08-13 This monograph presents new model based design methods for trajectory planning feedback stabilization state estimation and tracking control of distributed parameter systems governed by partial differential equations PDEs Flatness and backstepping techniques and their generalization to PDEs with higher dimensional spatial domain lie at the core of this treatise This includes the development of systematic late lumping design procedures and the deduction of semi numerical approaches using suitable approximation methods Theoretical developments are combined with both simulation examples and experimental results to bridge the gap between mathematical theory and control engineering practice in the rapidly evolving PDE control area The text is divided into five parts featuring a literature survey of paradigms and control design methods for PDE systems the first principle mathematical modeling of applications arising in heat and mass transfer interconnected multi agent systems and piezo actuated smart elastic structures the generalization of flatness based trajectory planning and feedforward control to parabolic and biharmonic PDE systems defined on general higher dimensional domains an extension of the backstepping approach to the feedback control and observer design for parabolic PDEs with parallelepiped domain and spatially and time varying parameters the development of design techniques to realize exponentially stabilizing tracking control the evaluation in simulations and experiments Control of Higher Dimensional PDEs Flatness and Backstepping Designs is an advanced research monograph for graduate students in applied mathematics control theory and related fields The book may serve as a reference to recent developments for researchers and control engineers interested in the analysis and control of systems governed by PDEs **Evolution**

Equations Kaïs Ammari, Stéphane Gerbi, 2018 The proceedings of a summer school held in 2015 whose theme was long time behavior and control of evolution equations Controller Design for Distributed Parameter Systems Kirsten A. Morris, 2020-06-01 This book addresses controller and estimator design for systems that vary both spatially and in time systems like fluid flow acoustic noise and flexible structures It includes coverage of the selection and placement of actuators and sensors for such distributed parameter systems The models for distributed parameter systems are coupled ordinary partial differential equations Approximations to the governing equations often of very high order are required and this complicates both controller design and optimization of the hardware locations Control system and estimator performance depends not only on the controller estimator design but also on the location of the hardware In helping the reader choose the best location for actuators and sensors the analysis provided in this book is crucial because neither intuition nor trial and error is foolproof especially where multiple sensors and actuators are required and moving hardware can be difficult and costly The mechatronic approach advocated in which controller design is integrated with actuator location can lead to better performance without increased cost Similarly better estimation can be obtained with carefully placed sensors The text shows

how proper hardware placement varies depending on whether disturbances are present whether the response should be reduced to an initial condition or whether controllability and or observability have to be optimized This book is aimed at non specialists interested in learning controller design for distributed parameter systems and the material presented has been used for student teaching The relevant basic systems theory is presented and followed by a description of controller synthesis using lumped approximations Numerical algorithms useful for efficient implementation in real engineering systems and practical computational challenges are also described and discussed

Dissipativity in Control Engineering Alexander Schaum,2021-07-19 Dissipativity as a natural mechanism of energy interchange is common to many physical systems that form the basis of modern automated control applications Over the last decades it has turned out as a useful concept that can be generalized and applied in an abstracted form to very different system setups including ordinary and partial differential equation models In this monograph the basic notions of stability dissipativity and systems theory are connected in order to establish a common basis for designing system monitoring and control schemes The approach is illustrated with a set of application examples covering finite and infinite dimensional models including a ship steering model the inverted pendulum chemical and biological reactors relaxation oscillators unstable heat equations and first order hyperbolic integro differential equations

Proceedings of 2021 5th Chinese Conference on Swarm Intelligence and Cooperative Control Zhang Ren,Mengyi Wang,Yongzhao Hua,2022-07-29 This book includes original peer reviewed research papers from the 2021 5th Chinese Conference on Swarm Intelligence and Cooperative Control CCSICC2021 held in Shenzhen China on January 19 22 2022 The topics covered include but are not limited to reviews and discussions of swarm intelligence basic theories on swarm intelligence swarm communication and networking swarm perception awareness and location swarm decision and planning cooperative control cooperative guidance swarm simulation and assessment The papers showcased here share the latest findings on theories algorithms and applications in swarm intelligence and cooperative control making the book a valuable asset for researchers engineers and university students alike

Control Theory and Inverse Problems Kaïs Ammari,Islam Boussaada,Chaker Jammazi,2024-11-07 This volume presents a timely overview of control theory and inverse problems and highlights recent advances in these active research areas The chapters are based on talks given at the spring school Control Theory Inverse Problems held in Monastir Tunisia in May 2023 In addition to providing a snapshot of these two areas chapters also highlight breakthroughs on more specific topics such as Control of hyperbolic systems The Helffer Nier Conjecture Rapid stabilization of the discretized Vlasov system Exponential stability of a delayed thermoelastic system Control Theory and Inverse Problems will be a valuable resource for both established researchers as well as more junior members of the community

Boundary Control of PDEs Miroslav Krstic,Andrey Smyshlyaev,2008

Adaptive Control of Hyperbolic PDEs Henrik Anfinssen,Ole Morten Aamo,2019-02-21 Adaptive Control of Linear Hyperbolic PDEs provides a comprehensive treatment of adaptive control of linear hyperbolic systems using the backstepping method It develops

adaptive control strategies for different combinations of measurements and actuators as well as for a range of different combinations of parameter uncertainty The book treats boundary control of systems of hyperbolic partial differential equations PDEs with uncertain parameters The authors develop designs for single equations as well as any number of coupled equations The designs are accompanied by mathematical proofs which allow the reader to gain insight into the technical challenges associated with adaptive control of hyperbolic PDEs and to get an overview of problems that are still open for further research Although stabilization of unstable systems by boundary control and boundary sensing are the particular focus state feedback designs are also presented The book also includes simulation examples with implementational details and graphical displays to give readers an insight into the performance of the proposed control algorithms as well as the computational details involved A library of MATLAB code supplies ready to use implementations of the control and estimation algorithms developed in the book allowing readers to tailor controllers for cases of their particular interest with little effort These implementations can be used for many different applications including pipe flows traffic flow electrical power lines and more Adaptive Control of Linear Hyperbolic PDEs is of value to researchers and practitioners in applied mathematics engineering and physics it contains a rich set of adaptive control designs including mathematical proofs and simulation demonstrations The book is also of interest to students looking to expand their knowledge of hyperbolic PDEs

Input-to-State Stability for PDEs Iasson Karafyllis, Miroslav Krstic, 2019-01-10 This book lays the foundation for the study of input to state stability ISS of partial differential equations PDEs predominantly of two classes parabolic and hyperbolic This foundation consists of new PDE specific tools In addition to developing ISS theorems equipped with gain estimates with respect to external disturbances the authors develop small gain stability theorems for systems involving PDEs A variety of system combinations are considered PDEs of either class with static maps PDEs again of either class with ODEs PDEs of the same class parabolic with parabolic and hyperbolic with hyperbolic and feedback loops of PDEs of different classes parabolic with hyperbolic In addition to stability results including ISS the text develops existence and uniqueness theory for all systems that are considered Many of these results answer for the first time the existence and uniqueness problems for many problems that have dominated the PDE control literature of the last two decades including for PDEs that include non local terms backstepping control designs which result in non local boundary conditions Input to State Stability for PDEs will interest applied mathematicians and control specialists researching PDEs either as graduate students or full time academics It also contains a large number of applications that are at the core of many scientific disciplines and so will be of importance for researchers in physics engineering biology social systems and others Boundary Feedback Control Design for Classes of Mixed-Type Partial Differential Equations Stephen Chen, 2019 The work in this dissertation summarizes some advancement in the theory of boundary controller design for coupled partial differential equations PDEs including a new interpretation of designing bilateral boundary controllers as equivalent coupled PDEs via a method dubbed folding In

particular systems of purely hyperbolic type purely parabolic type and mixed hyperbolic parabolic type are all explored in the context of boundary control The work centers around the method of infinite dimensional backstepping consisting of an non trivially invertible spatial transformation mapping to a system with desirable properties such stability of equilibria and convergence speed A companion kernel PDE must be solved to properly define the transform The transformations across the different classes of PDEs are similar and in certain cases identical however curious behavior arises from a heterogeneous mixed type PDE in which the companion kernel PDE becomes non standard The thesis studies some preliminary work into mixed type PDEs in an attempt to recover a more general backstepping design for linear PDE In the purely hyperbolic work a special case of a underactuated hyperbolic system is considered This is in opposition to pre existing literature which assumed a fully actuated system The classical backstepping boundary controller is modified for the underactuated hyperbolic case admitting a two tiered transformation approach in which the backstepping controller is augmented by a predictor based controller to achieve a finite time stability for the trivial solution of the system In the purely parabolic work the notion of the folding approach is introduced as an alternative design method to pre existing bilateral boundary control design work The folding approach admits additional design parameters for the control designer allowing the controls to be biased for differing performance indexes A complimentary state estimator is designed which allows for collocated point measurement at any arbitrary point in the domain independent of the control design The two are combined to achieve an output feedback control result Several results are given for mixed type PDE systems of hyperbolic parabolic type as well A first result involves a scalar system with coupling on the boundary and the interior The interior coupling necessitates more advanced techniques in the analysis of the companion kernel PDE particularly in showing well posedness These ideas are also applied to other higher order coupled systems of hyperbolic parabolic type including delay compensation for systems of parabolic PDEs and delay compensation for bilateral controller design of parabolic PDEs Both the notion of bilateral boundary control and mixed type PDE systems arise in short wavelength light generation In the state of the art light generation at the extreme ultraviolet EUV wavelengths instabilities in the light generation process potentially arise due to coupled plasma interactions with the generating process Phenomena such as ion acoustic waves free electron plasma diffusion magnetohydrodynamics and thermofluidics arise due to the interacting plasma introducing potential modes of instability This instability necessitates the introduction of feedback control which can be introduced via two controllers on either boundary of the process domain

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