Preface

Linear parameter varying (LPV) systems are described by linear differential equations whose describing data depend—possibly in a nonlinear fashion—on time-varying parameters. The goal of the LPV synthesis problem is to design a controller of the very same structure such that the overall controlled system satisfies certain desired specifications on stability and performance over the entire set of permissible parameter trajectories. Hence, the implementation of LPV controllers takes online measurements of the time-varying parameters into account in order to improve the performance over robust controllers, which are compensators without any adaptation capabilities. Since the time-varying parameters often admit the interpretation of describing the location of the system's operating point, LPV control methods are viewed as a viable alternative to classical gain-scheduling designs for controlling nonlinear systems. In particular, LPV control theory offers advantages over classical gain-scheduled control in that the resulting LPV controllers are automatically gain-scheduled, and no ad hoc methods of interpolation of gains are needed. In addition, it guarantees stability, performance, and robustness properties, which are generally difficult to achieve with traditional design methodologies. Last but not least, LPV synthesis exploits the power of available computational tools from convex optimization.

Since the introduction of the gain-scheduling paradigm about two decades ago (by Jeff Shamma—then at MIT—and his PhD advisor Michael Athans), the LPV framework has drawn the attention of many researchers all over the world and a significant body of related work has emerged. Unfortunately, the history of the theoretical developments and the applications of LPV theory have not yet been collectively addressed in a monograph. This volume seeks to bridge this gap by examining past, recent, and novel state-of-the-art methods and providing an outlook on modeling, identification, complexity reduction, performance analysis, and control design of time-varying and nonlinear systems described in the LPV framework. The book has an interdisciplinary character by emphasizing techniques that can be commonly applied in various engineering fields. It also includes a rich collection of illustrative applications in diverse domains which substantiates the effectiveness of the design methodology and provides pointers to open research directions.

The book is divided into three parts. Part I collects two chapters of a more tutorial character on the background of LPV systems. The chapter by Jeff Shamma introduces the role of LPV systems and the technical delicacies involved in analyzing stability properties of LPV systems. This contribution describes the essential ideas on how to handle LPV systems using techniques from convex optimization (linear matrix inequalities) and set-invariance methods, and it provides a nice compilation of references to the LPV literature. The chapter by Roland Tóth et al. gives a theoretical overview of prediction-error-based identification techniques for modeling LPV systems. It provides useful guidelines in order to choose suitable methods for the construction of LPV models that can be used for the application of the techniques in the remainder of the book.

In Part II, we gathered chapters that are devoted to the theoretical advancement of LPV analysis and synthesis methods. In Chap. 3 by Franco Blanchini et al. the problem of interpolating parametric controllers is considered, irrespective of the underlying design philosophy. By using the Youla–Kucera parameterization, it is revealed how to interpolate controllers for frozen parameters such that stability of the overall closed-loop system is preserved when the parameters vary arbitrarily fast. Maurício de Oliveira considers the construction of controllers whose structure matches the affine parameter dependence of the system for established LPV synthesis frameworks in Chap. 4. Controller design for systems linearized around trajectories leads to time-varying LPV systems for which a design approach is proposed in Chap. 5 by Mazen Farhood. To deal with multiple performance objectives including classical regulation constraints, Hakan Köroğlu develops a suitable design methodology for LPV systems in Chap. 6. A nonconservative state-feedback synthesis technique for switched LPV systems based on path-dependent Lyapunov functions is proposed by Ji-Woong Lee and Geir Dullerud in Chap. 7. Robustification of LPV controllers against disturbance inputs in the parameter measurements is the topic of Chap. 8 contributed by Masayuki Sato and Dimitri Peaucelle. In Chap. 9, Tri Tran et al. consider time-varying splitting systems in the context of model-predictive control, in which dissipation-based techniques similar to those appearing in LPV theory play a central role. Joost Veenman et al. propose an algorithm for designing gain-scheduled estimators that are robust against structured uncertainties described by general integral quadratic constraints (IQCs) in Chap. 10. The more theoretically oriented part is concluded by Chap. 11 on the design of delay-dependent output-feedback controllers for LPV systems that are affected by time delays, contributed by Rohit Zope et al.

Part III of the volume showcases concrete applications of LPV modeling and control techniques in a wide range of technological areas. To comply with industry standards, the authors Fabiano Daher Adegas et al. of Chap. 12 propose a structured controller synthesis algorithm for an LPV model of a wind turbine which includes features of fault tolerance and robustness. Small-satellite attitude regulation with magnetic actuators is improved by incorporating measurements of the magnetic field in the controller through LPV modeling and state-feedback synthesis, as demonstrated in Chap. 13 by Andrea Corti and Marco Lovera. Jan de Caigny et al. propose to model LPV systems by interpolation and apply it together with a variety of LPV synthesis approaches to a vibroacoustic application with high temperature sensitivity in Chap. 14. Anh-Lam Do et al. investigate how to control semi-active dampers in a quarter-car model in Chap. 15. Highly nonlinear flexible hypersonic air-breathing vehicles are controlled on the basis of the so-called gridding approach to LPV synthesis in Chap. 16 by Hunter Hughes and Fen Wu. Andreas Kominek et al. suggest tools for generating reduced order LPV models through system identification and provide an illustration for controlling a turbocharged combustion engine in Chap. 17. Freeway traffic control is the subject of Chap. 18, in which Tamas Luspay et al. use scheduling techniques for handling hard constraints and suppressing undesired phenomena on the network through disturbance attenuation. Elasticity generates resonance modes that might create performance limitations for controlling flexible systems; in Chap. 19, Peter Seiler et al. use LPV analysis to certify conventional controllers for NASA Dryden's X-53 active aeroelastic wing testbed and provide a comparison with their own synthesized LPV controller. The book is concluded with Chap. 20 addressing integrated vehicle chassis control in which Zoltan Szabo et al. provide an illustration of how to use the LPV technology for designing hierarchical control architectures.

It is our sincere hope that the readers will enjoy the breadth and depth of this collection of chapters on LPV theory and applications. Our special thanks go to Steven Elliot, the former Senior Editor—Engineering and Merry Stuber at Springer for their assistance throughout this project. Most importantly, we would like to thank all the contributors fortheir outstanding effort in composing their contributions to this book.

Houston, TX, USA — Javad Mohammadpour
Stuttgart, Germany — Carsten W. Scherer

http://www.springer.com/978-1-4614-1832-0

Control of Linear Parameter Varying Systems with
Applications
Mohammadpour, J.; Scherer, C.W. (Eds.)
2012, XVIII, 550 p., Hardcover
ISBN: 978-1-4614-1832-0