Preface

This monograph provides a detailed practical and theoretical introduction to nonlinear control system design for the use of engineers and scientists. It will present systematic design methods, such as those that have been developed for linear systems, to address nonlinear problems. Linear control theory has a limited ability to tackle highly nonlinear systems. Our purpose here is to extend the recent developments in convex optimization of linear systems to nonlinear systems. A new nonlinear control algorithm known as "dynamic surface control (DSC)" using convex optimization is presented. It provides an effective design methodology for designing robust controllers for uncertain nonlinear systems. Sample applications will be provided to demonstrate how DSC can be effectively used to solve design problems in both the automotive and robotic fields.

This book is primarily intended for graduate students in nonlinear control theory, but can also serve as a source of applications for researchers in control design in the area of mechatronic systems such as automotive and robotic control. A wide variety of problems ranging from the design of DSC to extensions to output feedback, input saturation, multi-input multi-output, and fault tolerant control are considered. The results are shown to apply to a class of nonlinear and interconnected systems, in particular to automated vehicle control and biped robot control.

This book is divided in two parts. The first part addresses theoretical results for nonlinear control system design. In Chap. 2 a new method of analyzing the stability of a class of nonlinear systems by using the DSC design approach is presented. Based on quadratic stability theory, feasibility of the fixed controller gains for quadratic stabilization and tracking can be tested by solving a convex optimization problem. This approach is extended to problems with consideration of the following constraints, as we advance from chapter to chapter:

- a class of uncertainties: Chap. 3
- output feedback: Chap. 4
- input saturation: Chap. 5
- multi-input multi-output: Chap. 6.

The second part of the book introduces applications of theoretical results to vehicle and robot control. The relation between chapters and the results of the first part of the book is summarized as follows:

- Fault classification for vehicle control in Chap. 7: extension of the results in Chaps. 2 and 3 to switched nonlinear systems
- Fault tolerant control for an automated vehicle in Chap. 8: extension of the results in Chap. 4 to switched nonlinear systems
- Biped robot control in Chap. 9: application of the results in Chaps. 2 and 6 to interconnected mechanical systems.

The authors are particularly indebted to former graduate students in the Vehicle Dynamics and Control Lab at UC Berkeley: J. Green and M. Won contributed to the idea of multiple sliding surface control; S. Choi and D. McMahon conducted engine and vehicle control using multiple sliding surface control; D. Swaroop and C. Gerdes triggered the use of dynamic surface control for uncertain nonlinear systems and applied the idea to vehicle control; P. Yip extended the result to adaptive dynamic surface control; S. Raghavan and R. Rajamani provided a systematic procedure for nonlinear observer design. There are probably more names we should acknowledge for their contributions in a long line of simulations and applications. We would like to thank each one of them.

We also want to acknowledge the collaboration with California PATH at UC Berkeley. Especially more than 15 researchers including the first author developed the automated transit bus and demonstrated its feasibility in 2003, and some of results and pictures are included in this book. The implementation of the longitudinal control described in this book would not have succeeded without A. Howell, S. Dickey, and many other researchers at the California PATH research program.

The first author wishes to thank his former students at the Automatic Control Lab at Ajou University; J. Choi worked on simulations of the biped robot control. He also wants to thank his family for their endless support: his wife Moonjeung and sons Ryan and Kyle. Furthermore, he is grateful to Ajou University and UC Berkeley for providing an environment to write this monograph at Berkeley.

The second author would like to thank his wife Carlyle and daughters Ashley, Tristan and Ryan for their interest and support over the years. He would also like to thank his many, many students, who have taught him so much.

Suwon, Korea — Bongsob Song
Berkeley, California, USA — J. Karl Hedrick

http://www.springer.com/978-0-85729-631-3

Dynamic Surface Control of Uncertain Nonlinear Systems
An LMI Approach
Song, B.; Hedrick, J.K.
2011, XIV, 254 p., Hardcover
ISBN: 978-0-85729-631-3