Preface 1

This book consists of three parts. Each part focuses on a field of research that has been central to the scientific career of Henk Nijmeijer; namely (1) nonlinear control systems, (2) synchronization in networked systems, (3) control of nonlinear mechanical systems.

Part I on "Nonlinear Control Systems" commences with a contribution of Arjan van der Schaft entitled "Controlled Invariant Distributions and Differential Properties." Henk Nijmeijer and Arjan van der Schaft defended their Ph.D. theses on the same day and worked under the supervision of the same "promotor" (Jan C. Willems) on the topic of nonlinear geometric control theory, ultimately culminating in the well-known textbook entitled "Nonlinear Dynamical Control Systems," published by Springer in 1990. Chapter 1 of this book revisits the topic of controlled invariant distributions as also studied by Henk Nijmeijer and Arjan der Schaft in their earlier work and makes a direct link to the topics of convergent dynamics and contraction analysis that recently received wide attention in the systems and control community.

Chapter 2 is contributed by Tengfei Liu and Zhong-Ping Jiang and presents results on the distributed control of nonlinear systems. In particular, small-gain methods for the distributed control of nonlinear systems are proposed and an application to the distributed formation control problem of nonholonomic mobile robots is detailed. The tracking control of mobile robots has been a topic of fruitful collaboration between Henk Nijmeijer and Zhong-Ping Jiang for many years.

Chapter 3 is contributed by Alexey Pavlov and Nathan van de Wouw. This chapter reviews the class of nonlinear convergent systems and highlights many applications of the convergence property to nonlinear analysis and control problems, such as global output regulation, frequency domain analysis of nonlinear systems, model reduction, stable inversion, and extremum seeking control. Many of these recent results have culminated from earlier joint research of the authors with Henk Nijmeijer, when Alexey Pavlov performed his Ph.D. studies at the Eindhoven University of Technology in the early 2000s.

Part II of this book is devoted to one of Henk Nijmeijer's favorite topics of research: synchronization. It starts with a chapter written by Elena Panteley and Antonio Lora, which focusses on the synchronization and emergent behavior in networks of heterogeneous systems. The authors bring forth a new perspective on how to analyze synchronization for a network of systems with nonidentical dynamics.

Toshiki Oguchi authors Chap. 5, in which the topics of state predictors and anticipating synchronization for nonlinear delay systems are addressed. These topics have been a mutual and on-going research interest of the author and Henk Nijmeijer.

Chapter 6, contributed by Wim Michiels, focuses on delay systems. It centers on delays effects in dynamical systems and provides insightful analysis and control interpretations. Extensions of these results towards networks of interconnected nonlinear dynamical systems are discussed, with a focus on the synchronization problem.

Part II of the book closes with a contribution entitled "Emergence of Oscillations in Networks of Time-Delay Coupled Inert Systems" authored by Erik Steur and Sasha Pogromski. It presents results of the emergence of oscillations in networks of nonlinear single-input single-output systems that interact via linear, time-delayed coupling functions.

Part III of this book concerns the control of nonlinear mechanical systems. It opens with Chap. 8 authored by Dennis Belleter and Kristin Pettersen on "Leader-Follower Synchronisation for a Class of Underactuated Systems." It deals with the control of marine vehicles, such as underactuated autonomous surface vessels and autonomous underwater vehicles, a topic of joint interest to Henk Nijmeijer and Kristin Pettersen.

Chapter 9, entitled "Position Control via Force Feedback for a Class of Standard Mechanical Systems in the Port-Hamiltonian Framework," is authored by Mauricio Munoz-Arias, Jacquelien Scherpen, and Daniel Dirksz. It presents position control strategies for standard mechanical systems in the port-Hamiltonian framework via force feedback.

The book closes with a contribution of Krzysztof Tchoń "The Endogenous Configuration Space Approach: An Intersection of Robotics and Control Theory." The endogenous configuration approach is a control theory oriented methodology of robotics research, dedicated to mobile manipulators, which leads to motion planning algorithms.

Eindhoven   Nathan van de Wouw
February 2016   Erjen Lefeber
                                                                          Ines Lopez Arteaga

Preface 2

This book has been written at the occasion of the 60th birthday of Prof. Henk Nijmeijer on March 16, 2015, and commemorates the role of Henk Nijmeijer in both the Dutch and the international (nonlinear) systems and control communities.

At the occasion of this birthday, the Dynamics and Control group of the Department of Mechanical Engineering of the Eindhoven University of Technology, the Netherlands, (chaired by Henk Nijmeijer) has taken the initiative to organize a one-day international workshop on "Nonlinear Systems" in honor of Henk Nijmeijer's sixtieth birthday, which was organized on January 21, 2016, in the Auditorium of the Eindhoven University of Technology, Eindhoven, the Netherlands.

During this workshop, Henk's colleagues, international collaborators, and former students have contributed by giving a seminar on a topic related to their joint research.

This book collects research contributions of many international scientists and former students of Henk, with whom he has had extensive research collaborations and/or who have been inspired and supported by him to take on challenging and

exciting research problems in the fields of nonlinear control systems, synchronization, coordinated and distributed control, model reduction and the dynamic analysis, and control of mechanical systems.

After his M.Sc. graduation (cum laude) in 1979 at the Rijksuniversiteit Groningen (RUG), the Netherlands, Henk Nijmeijer performed his Ph.D. studies (from 1980 to 1983) at the Center for Mathematics and Informatics (CWI) in Amsterdam, the Netherlands. His Ph.D. research focused on nonlinear geometric control theory and resulted, under the supervision of Jan van Schuppen and promotor Jan C. Willems (University of Groningen), in the Ph.D. thesis entitled "Nonlinear multivariable control: a differential geometric approach." At that time, Henk had intensive research collaborations with Arjan van der Schaft, who was also performing his Ph.D. research under the supervision of Jan C. Willems. This collaboration has ultimately led to the well-known textbook "Nonlinear Dynamical Control Systems", published by Springer in 1990, based on their lecture notes for a yearly taught DISC (Dutch Institute for Systems and Control) graduate course since 1987. Notably, a new edition of this book will appear in 2016, further evidencing the lasting impact of this book on the international nonlinear systems community.

In 1983, Henk took on a position as Assistant Professor, and later as Associate Professor, at the Department of Applied Mathematics of the University of Twente, Enschede, the Netherlands. His work remained focused on nonlinear control systems, but in the 1990s he also increasingly engaged in research related to the control of nonlinear mechanical systems, such as mobile robots and robotic manipulators.

The combination of his strong expertise on the mathematical foundations of nonlinear control theory and his interest in the dynamics and control of mechanical systems has undoubtedly played a role in Henk taking on a part-time Full Professor position in 1997 at the Department of Mechanical Engineering of the Eindhoven University of Technology, Eindhoven, the Netherlands. This part-time position ultimately led to a full-time professor position at this department in 2000, where he started the "Dynamics and Control" group, which he still chairs today. The name of the group reflects Henk's unique affinity with both the modeling and analysis of dynamical systems and control theory. Since 2000, Henk has continued to pursue fundamental research in nonlinear systems and control on topics such as output regulation, synchronization, hybrid systems, networked and delay systems, and model reduction, but combined this successfully with an increasing focus on engineering applications, such as vehicle dynamics, robotics, mechanical design, acoustics, mechatronics, and cooperative and automated driving. In doing so, he has been a mentor and an inspiring colleague for many of his co-workers in the group, which grew to be an internationally recognized center for research and teaching in dynamical systems and control, as evidenced by the excellent ratings from international review committees concerning the review periods of 2001–2006 and 2007–2012. Affiliated to Mechanical Engineering Department at the Eindhoven University of Technology, Henk has engaged in collaborations with both Dutch industries and industries abroad, such as for example ASML, Philips, Bosch Rexroth B.V., Océ, Kulicke and Soffa, Ford, DAF, FEI Company, VDL, CCM, Shell, Statoil, NXP, Prodrive, Vredestein, Honeywell, MAN, MTT, and many

more. The Dynamics and Control group also generated the spin-off companies Sorama, focusing on sound imaging, and Rose B.V., focusing on robotics for care. As such, Henk effectively strives to combine fundamental research with its valorization in industry and society.

Henk has also strongly contributed to the education of new generations of engineers and scientists in the field of dynamics and control, for which there is a great need in the high-tech "Brainport" region of Eindhoven in the Netherlands. Under the supervision of Henk Nijmeijer, 35 Ph.D. students and over 250 M.Sc. students have graduated since the year 2000 at the Eindhoven University of Technology. Moreover, he has also played an important role in the Dutch Institute for Systems and Control (DISC), the Dutch national graduate school for systems and control. In fact, he was already playing an important role in the Dutch Network of Systems and Control, which has offered a national graduate program in systems and control since 1987 and is the predecessor of DISC. He has been involved in DISC since its founding in 1995 by lecturing a course on nonlinear control systems with Arjan van der Schaft for many years, and by organizing summer schools on the control of mechanical systems. Since 2000, he has been a DISC board member and, as of 2015, Henk became Scientific Director of DISC.

Henk has published a large number of journal and conference papers, and several books, including the classical "Nonlinear Dynamical Control Systems" (Springer Verlag, 1990, co-author Arjan van der Schaft), "Synchronization of Mechanical Systems" (2003, World Scientific, together with Alejandro Rodriguez-Angeles), "Dynamics and Bifurcations of Non-smooth Mechanical Systems" (Springer Verlag, 2004, together with Remco Leine), "Uniform Output Regulation of Nonlinear Systems: A Convergent Dynamics Approach" (Birkhäuser, 2005, together with Alexey Pavlov and Nathan van de Wouw), and many more.

Henk has also been strongly committed to the international systems and control community and has served our community in many ways. He is Council Member of the International Federation of Automatic Control (IFAC), and is/has been the organizer and/or IPC Chair of numerous international conferences and workshops. He is editor-in-chief of the Journal of Applied Mathematics, editor of the Communications on Nonlinear Systems and Numerical Simulation, corresponding editor of the SIAM Journal on Control and Optimization, and is/has been board member of the International Journal of Control, Automatica, the Journal of Dynamical Control Systems, the International Journal of Bifurcation and Chaos, the International Journal of Robust and Nonlinear Control, the Journal of Nonlinear Dynamics, and the Journal of Applied Mathematics and Computer Science.

Henk became a Fellow of the IEEE in 2000 and was awarded the IEE Heaviside Premium in 1987. Together with Kristin Pettersen, he received the 2006 IEEE Transactions on Control Systems Technology Outstanding Paper Award. Recently, he also received the 2015 IEEE Control Systems Technology Award (together with Marcel Heertjes, Alexey Pavlov and Nathan van de Wouw). These awards are exemplary of his remarkable achievements and the impact of his work in the field.

Dear Henk, this book is dedicated to you by all editors and authors. Thank you very much for inspiring us to take on exciting new research challenges in nonlinear dynamics and control, for your everlasting support and mentorship. It has been a great pleasure working with you and we hope to continue to do so for many years to come.

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