Preface

The idea for this book grew out of a course given at a winter school of the International Doctoral Program "Identification, Optimization and Control with Applications in Modern Technologies" in Schloss Thurnau in March 2009. Initially, the main purpose of this course was to present results on stability and performance analysis of nonlinear model predictive control algorithms, which had at that time recently been obtained by ourselves and coauthors. However, we soon realized that both the course and even more the book would be inevitably incomplete without a comprehensive coverage of classical results in the area of nonlinear model predictive control and without the discussion of important topics beyond stability and performance, like feasibility, robustness, and numerical methods.

As a result, this book has become a mixture between a research monograph and an advanced textbook. On the one hand, the book presents original research results obtained by ourselves and coauthors during the last five years in a comprehensive and self contained way. On the other hand, the book also presents a number of results—both classical and more recent—of other authors. Furthermore, we have included a lot of background information from mathematical systems theory, optimal control, numerical analysis and optimization to make the book accessible to graduate students—on PhD and Master level—from applied mathematics and control engineering alike. Finally, via our web page www.nmpc-book.com we provide MATLAB and C++ software for all examples in this book, which enables the reader to perform his or her own numerical experiments. For reading this book, we assume a basic familiarity with control systems, their state space representation as well as with concepts like feedback and stability as provided, e.g., in undergraduate courses on control engineering or in courses on mathematical systems and control theory in an applied mathematics curriculum. However, no particular knowledge of nonlinear systems theory is assumed. Substantial parts of the systems theoretic chapters of the book have been used by us for a lecture on nonlinear model predictive control for master students in applied mathematics and we believe that the book is well suited for this purpose. More advanced concepts like time varying formulations or peculiarities of sampled data systems can be easily skipped if only time invariant problems or discrete time systems shall be treated.

The book centers around two main topics: systems theoretic properties of nonlinear model predictive control schemes on the one hand and numerical algorithms on the other hand; for a comprehensive description of the contents we refer to Sect. 1.3. As such, the book is somewhat more theoretical than engineering or application oriented monographs on nonlinear model predictive control, which are furthermore often focused on linear methods.

Within the nonlinear model predictive control literature, distinctive features of this book are the comprehensive treatment of schemes without stabilizing terminal constraints and the in depth discussion of performance issues via infinite horizon suboptimality estimates, both with and without stabilizing terminal constraints. The key for the analysis in the systems theoretic part of this book is a uniform way of interpreting both classes of schemes as relaxed versions of infinite horizon optimal control problems. The *relaxed dynamic programming* framework developed in Chap. 4 is thus a cornerstone of this book, even though we do not use dynamic programming for actually solving nonlinear model predictive control problems; for this task we prefer direct optimization methods as described in the last chapter of this book, since they also allow for the numerical treatment of high dimensional systems.

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