

Contents

1	Introduction	1
1.1	What Is Nonlinear Model Predictive Control?	1
1.2	Where Did NMPC Come From?	3
1.3	How Is This Book Organized?	5
1.4	What Is Not Covered in This Book?	9
	References	10
2	Discrete Time and Sampled Data Systems	13
2.1	Discrete Time Systems	13
2.2	Sampled Data Systems	16
2.3	Stability of Discrete Time Systems	29
2.4	Stability of Sampled Data Systems	37
2.5	Notes and Extensions	40
	Problems	41
	References	43
3	Nonlinear Model Predictive Control	45
3.1	The Basic NMPC Algorithm	45
3.2	Constraints	48
3.3	Variants of the Basic NMPC Algorithms	52
3.4	The Dynamic Programming Principle	58
3.5	Notes and Extensions	64
	Problems	67
	References	68
4	Infinite Horizon Optimal Control	71
4.1	Definition and Well Posedness of the Problem	71
4.2	The Dynamic Programming Principle	74
4.3	Relaxed Dynamic Programming	80
4.4	Notes and Extensions	86
	Problems	87
	References	89

5	Stability and Suboptimality Using Stabilizing Terminal	
	Conditions	91
5.1	The Relaxed Dynamic Programming Approach	91
5.2	Equilibrium Endpoint Constraint	92
5.3	Lyapunov Function Terminal Cost	99
5.4	Suboptimality and Inverse Optimality	107
5.5	Notes and Extensions	115
	Problems	116
	References	118
6	Stability and Suboptimality Without Stabilizing Terminal	
	Conditions	121
6.1	Setting and Preliminaries	121
6.2	Bounds on V_N and Asymptotic Controllability with Respect to ℓ	125
6.3	Implications of the Bound on V_N	129
6.4	Computation of α	130
6.5	Main Stability and Performance Results	135
6.6	Design of Good Stage Costs ℓ	144
6.7	Semiglobal and Practical Asymptotic Stability	154
6.8	Proof of Proposition 6.18	163
6.9	Notes and Extensions	172
	Problems	174
	References	176
7	Feasibility and Robustness	177
7.1	The Feasibility Problem	177
7.2	Feasibility of Unconstrained NMPC Using Exit Sets	180
7.3	Feasibility of Unconstrained NMPC Using Stability	184
7.4	Comparing NMPC with and Without Terminal Conditions	188
7.5	Robustness: Basic Definition and Concepts	192
7.6	Robustness Without State Constraints	194
7.7	Examples for Nonrobustness Under State Constraints	199
7.8	Robustness with State Constraints via Robust-Optimal Feasibility	204
7.9	Robustness with State Constraints via Continuity of V_N	209
7.10	Notes and Extensions	215
	Problems	217
	References	218
8	Economic NMPC	221
8.1	Setting	221
8.2	Averaged Performance with Terminal Conditions	223
8.3	Asymptotic Stability with Terminal Conditions	227
8.4	Non-averaged and Transient Performance with Terminal Conditions	231

- 8.5 Averaged Optimality Without Terminal Conditions 239
- 8.6 Practical Asymptotic Stability Without Terminal
Conditions 243
- 8.7 Non-averaged and Transient Performance Without
Terminal Conditions 248
- 8.8 Notes and Extensions 255
- Problems 256
- References 257
- 9 Distributed NMPC 259**
 - 9.1 Background and Problem Formulation 259
 - 9.2 Classification of Connectedness 261
 - 9.3 Problem Classes for Different Levels of Connectedness 272
 - 9.4 Asymptotic Stability and Convergence 276
 - 9.5 Communication and Coordination Schemes 281
 - 9.6 Notes and Extensions 292
 - Problems 293
 - References 294
- 10 Variants and Extensions 297**
 - 10.1 Schemes with Mixed Terminal Conditions 297
 - 10.2 Unconstrained NMPC with Terminal Weights 301
 - 10.3 Nonpositive Definite Stage Cost 302
 - 10.4 Multistep NMPC-Feedback Laws 306
 - 10.5 Fast Sampling 308
 - 10.6 Compensation of Computation Times 312
 - 10.7 Online Measurement of α 316
 - 10.8 Adaptive Optimization Horizon 325
 - 10.9 Nonoptimal NMPC 332
 - References 341
- 11 Numerical Discretization 343**
 - 11.1 Basic Solution Methods 343
 - 11.2 Convergence Theory 348
 - 11.3 Adaptive Step Size Control 353
 - 11.4 Using the Methods Within the NMPC Algorithms 357
 - 11.5 Numerical Approximation Errors and Stability 359
 - 11.6 Notes and Extensions 363
 - Problems 365
 - References 366
- 12 Numerical Optimal Control of Nonlinear Systems 367**
 - 12.1 Discretization of the NMPC Problem 367
 - 12.2 Unconstrained Optimization 380
 - 12.3 Constrained Optimization 385
 - 12.4 Implementation Issues in NMPC 408

12.5	Warm Start of the NMPC Optimization	418
12.6	Nonoptimal NMPC.	426
12.7	Notes and Extensions	430
	Problems.	432
	References.	432
	Appendix A: NMPC Software Supporting This Book	435
	Appendix B: Glossary.	441
	Index	449



<http://www.springer.com/978-3-319-46023-9>

Nonlinear Model Predictive Control

Theory and Algorithms

Grüne, L.; Pannek, J.

2017, XIV, 456 p. 80 illus., 22 illus. in color. With online files/update., Hardcover

ISBN: 978-3-319-46023-9