

---

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Control Systems	1
1.2	Concept of Receding Horizon Controls	3
1.3	Receding Horizon Filters and Output Feedback Receding Horizon Controls	7
1.4	Predictive Controls	8
1.5	Advantages of Receding Horizon Controls	9
1.6	About This Book	11
1.7	References	15
<b>2</b>	<b>Optimal Controls on Finite and Infinite Horizons: A Review</b>	<b>17</b>
2.1	Introduction	17
2.2	Optimal Control for General Systems	18
2.2.1	Optimal Control Based on Minimum Criterion	18
2.2.2	Optimal Control Based on Minimax Criterion	24
2.3	Linear Optimal Control with State Feedback	26
2.3.1	Linear Quadratic Controls Based on Minimum Criterion	26
2.3.2	$H_\infty$ Control Based on Minimax Criterion	42
2.4	Optimal Filters	49
2.4.1	Kalman Filter on Minimum Criterion	49
2.4.2	$H_\infty$ Filter on Minimax Criterion	52
2.4.3	Kalman Filters on Minimax Criterion	56
2.5	Output Feedback Optimal Control	57
2.5.1	Linear Quadratic Gaussian Control on Minimum Criterion	58
2.5.2	Output Feedback $H_\infty$ Control on Minimax Criterion	61
2.6	Linear Optimal Controls via Linear Matrix Inequality	66
2.6.1	Infinite Horizon Linear Quadratic Control via Linear Matrix Inequality	66

2.6.2	Infinite Horizon $H_\infty$ Control via Linear Matrix Inequality .....	68
2.7	* $H_2$ Controls .....	70
2.8	References .....	74
2.9	Problems .....	76
<b>3</b>	<b>State Feedback Receding Horizon Controls .....</b>	<b>83</b>
3.1	Introduction .....	83
3.2	Receding Horizon Controls in Predictive Forms .....	84
3.2.1	Predictive Forms .....	84
3.2.2	Performance Criteria in Predictive Forms .....	85
3.3	Receding Horizon Control Based on Minimum Criteria .....	87
3.3.1	Receding Horizon Linear Quadratic Control .....	87
3.3.2	Simple Notation for Time-invariant Systems .....	91
3.3.3	Monotonicity of the Optimal Cost .....	95
3.3.4	Stability of Receding Horizon Linear Quadratic Control .....	104
3.3.5	Additional Properties of Receding Horizon Linear Quadratic Control .....	115
3.3.6	A Special Case of Input–Output Systems .....	122
3.4	Receding Horizon Control Based on Minimax Criteria .....	125
3.4.1	Receding Horizon $H_\infty$ Control .....	125
3.4.2	Monotonicity of the Saddle-point Optimal Cost .....	128
3.4.3	Stability of Receding Horizon $H_\infty$ Control .....	133
3.4.4	Additional Properties .....	138
3.5	Receding Horizon Control via Linear Matrix Inequality Forms .....	139
3.5.1	Computation of Cost Monotonicity Condition .....	139
3.5.2	Receding Horizon Linear Quadratic Control via Batch and Linear Matrix Inequality Forms .....	143
3.5.3	Receding Horizon $H_\infty$ Control via Batch and Linear Matrix Inequality Forms .....	148
3.6	References .....	150
3.7	Problems .....	151
<b>4</b>	<b>Receding Horizon Filters .....</b>	<b>159</b>
4.1	Introduction .....	159
4.2	Dual Infinite Impulse Response Filter Based on Minimum Criterion .....	161
4.3	Optimal Finite Impulse Response Filters Based on Minimum Criterion .....	165
4.3.1	Linear Unbiased Finite Impulse Response Filters .....	165
4.3.2	Minimum Variance Finite Impulse Response Filters with Nonsingular $A$ .....	167
4.3.3	* Minimum Variance Finite Impulse Response Filters with General $A$ .....	177

4.3.4	Numerical Examples for Minimum Variance Finite Impulse Response Filters .....	188
4.4	Dual Infinite Impulse Response Filters Based on Minimax Criterion .....	190
4.5	Finite Impulse Response Filters Based on Minimax Criterion .....	195
4.5.1	Linear Unbiased Finite Impulse Response Filters .....	195
4.5.2	$L_2$ - $E$ Finite Impulse Response Filters .....	197
4.5.3	$H_\infty$ Finite Impulse Response Filter .....	202
4.5.4	* $H_2/H_\infty$ Finite Impulse Response Filters .....	204
4.6	References .....	207
4.7	Problems .....	209
<b>5</b>	<b>Output Feedback Receding Horizon Controls .....</b>	<b>217</b>
5.1	Introduction .....	217
5.2	State-observer-based Output Feedback Controls .....	218
5.3	Predictor-based Output Feedback Controls .....	220
5.4	A Special Case of Input-Output Systems of General Predictive Control .....	222
5.5	Finite Memory Control Based on Minimum Criterion .....	227
5.5.1	Finite Memory Control and Unbiased Condition .....	227
5.5.2	Linear Quadratic Finite Memory Control .....	230
5.5.3	* Linear Quadratic Finite Memory Control with General $A$ .....	235
5.5.4	Properties of Linear Quadratic Finite Memory Control .....	239
5.6	Finite Memory Control Based on Minimax Criterion .....	244
5.6.1	Finite Memory Control and Unbiased Condition .....	244
5.6.2	$L_2$ - $E$ Finite Memory Controls .....	245
5.6.3	$H_\infty$ Finite Memory Controls .....	250
5.6.4	* $H_2/H_\infty$ Finite Memory Controls .....	254
5.7	References .....	256
5.8	Problems .....	256
<b>6</b>	<b>Constrained Receding Horizon Controls .....</b>	<b>261</b>
6.1	Introduction .....	261
6.2	Reachable and Maximal Output Admissible Sets .....	262
6.3	Constrained Receding Horizon Control with Terminal Equality Constraint .....	269
6.4	Constrained Receding Horizon Control with Terminal Set Constraint .....	272
6.5	Constrained Receding Horizon Control with Free Terminal Cost .....	277
6.6	Constrained Receding Horizon Control with Mixed Constraints .....	284

6.7	Constrained Output Feedback Receding Horizon Control . . . . .	286
6.8	References . . . . .	289
6.9	Problems . . . . .	290
<b>7</b>	<b>Nonlinear Receding Horizon Controls . . . . .</b>	<b>297</b>
7.1	Introduction . . . . .	297
7.2	Nonlinear Receding Horizon Control with Terminal Equality Constraint . . . . .	298
7.3	Nonlinear Receding Horizon Control with Terminal Set Constraints . . . . .	300
7.4	Nonlinear Receding Horizon Control with Free Terminal Cost .	304
7.5	Nonlinear Receding Horizon Control with Infinite Cost Horizon . . . . .	311
7.6	Nonlinear Receding Horizon Minimax Control with Free Terminal Cost . . . . .	313
7.7	References . . . . .	316
7.8	Problems . . . . .	316
<b>A</b>	<b>Matrix Equality and Matrix Calculus . . . . .</b>	<b>323</b>
A.1	Useful Inversion Formulae . . . . .	323
A.2	Matrix Calculus . . . . .	325
<b>B</b>	<b>System Theory . . . . .</b>	<b>327</b>
B.1	Controllability and Observability . . . . .	327
B.2	Stability Theory . . . . .	330
B.3	Lyapunov and Riccati Matrix Equations . . . . .	331
<b>C</b>	<b>Random Variables . . . . .</b>	<b>335</b>
C.1	Random Variables . . . . .	335
C.2	Gaussian Random Variable . . . . .	336
C.3	Random Process . . . . .	339
<b>D</b>	<b>Linear Matrix Inequalities and Semidefinite Programming .</b>	<b>341</b>
D.1	Linear Matrix Inequalities . . . . .	341
D.2	Semidefinite Programming . . . . .	343
<b>E</b>	<b>Survey on Applications . . . . .</b>	<b>347</b>
<b>F</b>	<b>MATLAB<sup>®</sup> Programs . . . . .</b>	<b>349</b>
	<b>References . . . . .</b>	<b>367</b>
	<b>Index . . . . .</b>	<b>375</b>

Receding Horizon Control

Model Predictive Control for State Models

Kwon, W.H.; Han, S.H.

2005, XIV, 380 p. 51 illus. With online files/update.,

Softcover

ISBN: 978-1-84628-024-5