

Contents

Preface	x1
1. Introduction	1
1.1 Stability of Linear Systems	5
1.2 Variance of Linear Stochastic Systems	8
1.3 Quadratic Performance Measure	9
1.4 Book Organization	11
1.5 References	15
2. Continuous Algebraic Lyapunov Equation	21
2.1 Explicit Solutions	22
2.1.1 Expansion Methods	22
2.1.2 Skew-Symmetric Matrix Approach	30
2.1.3 Special Cases	31
2.2 Solution Bounds	39
2.2.1 Eigenvalue Bounds	40
2.2.2 Trace Bounds	56
2.2.3 Determinant Bounds	59
2.3 Numerical Solutions	62
2.3.1 Bartels and Stewart Algorithm	66
2.4 Summary	70
2.5 References	71
3. Discrete Algebraic Lyapunov Equation	79
3.1 Explicit Solutions	80
3.1.1 Bilinear Transformation	80
3.1.2 Jordan Form Technique	83
3.1.3 Skew-Symmetric Matrix Approach	84
3.2 Bounds of Solution's Attributes	85
3.2.1 Eigenvalue Bounds	85
3.2.2 Trace Bounds	90
3.2.3 Determinant Bounds	94
3.3 Numerical Solutions	99
3.4 Summary	101
3.5 References	102

4. Differential and Difference Lyapunov Equations	107
4.1 Explicit Solutions	108
4.1.1 Differential Lyapunov Equation	108
4.1.2 Difference Lyapunov Equation	110
4.2 Bounds of Solution's Attributes	111
4.2.1 Eigenvalue Bounds	111
4.2.2 Trace Bounds	114
4.2.3 Determinant Bounds	115
4.2.4 Solution Bounds	116
4.3 Numerical Solutions	116
4.4 Singularly Perturbed and Weakly Coupled Systems	120
4.4.1 Singularly Perturbed Differential Lyapunov Equation	121
4.4.1.1 Case Study: A DC Motor	123
4.4.2 Weakly Coupled Differential Lyapunov Equation	125
4.4.3 Singularly Perturbed Difference Lyapunov Equation	127
4.4.4 Weakly Coupled Difference Lyapunov Equation	128
4.5 Coupled Differential Lyapunov Equations	128
4.6 Summary	130
4.7 References	130
5. Algebraic Lyapunov Equations with Small Parameters	133
5.1 Singularly Perturbed Continuous Lyapunov Equation	136
5.2 Weakly Coupled Continuous Lyapunov Equation	141
5.3 Singularly Perturbed Discrete Systems	143
5.3.1 Parallel Algorithm for Discrete Algebraic Lyapunov Equation	143
5.3.2 Case Study: An F-8 Aircraft	147
5.4 Recursive Methods for Weakly Coupled Discrete Systems	148
5.4.1 Parallel Algorithm for Discrete Algebraic Lyapunov Equation	148
5.4.2 Case Study: Discrete Catalytic Cracker	150
5.5 Summary	150
5.6 References	151
6. Stability Robustness and Sensitivity of Lyapunov Equation	155
6.1 Stability Robustness	155
6.2 Sensitivity	162
6.2.1 Sensitivity of the Continuous Algebraic Lyapunov Equation	162
6.2.2 Sensitivity of the Discrete Algebraic Lyapunov Equation	165
6.3 References	166

7. Iterative Methods and Parallel Algorithms	169
7.1 Smith's Algorithm	170
7.2 ADI Iterative Method	172
7.3 SOR Iterative Method	174
7.4 Parallel Algorithms	175
7.5 Parallel Algorithms for Coupled Lyapunov Equations	178
7.5.1 Continuous Coupled Algebraic Lyapunov Equations	178
7.5.2 Discrete Coupled Algebraic Lyapunov Equations	181
7.6 Comments	184
7.7 References	185
8. Lyapunov Iterations	189
8.1 Kleinman's Algorithm for Riccati Equation	190
8.2 Lyapunov Iterations for Jump Parameter Linear Systems	195
8.3 Lyapunov Iterations for Nash Differential Games	208
8.4 Lyapunov Iterations for Output Feedback Control	215
8.4.1 Case Study: Fluid Catalytic Cracker	217
8.5 Comments	218
8.6 References	218
9. Concluding Remarks	223
9.1 Sylvester Equations	223
9.2 Related Topics	227
9.3 Applications	228
9.3.1 Case Study: Magnetic Tape Control System	231
9.3.2 Case Study: Aircraft under Wind Disturbances	232
9.4 Comments	233
9.5 References	234
Appendix	243
Matrix Inequalities	243
Index	251