Contents

1. Introduction **1**

2. Background and Preliminaries **7**
2.1. Dynamical systems and stability 7
2.2. Discrete-time linear systems 9
2.3. Event-triggered and self-triggered control 11
2.4. Set-valued estimation 13
2.4.1. Set-valued estimates from linear estimator dynamics 14
2.4.2. Set-valued moving-horizon estimation 15
2.5. Model predictive control 16

3. Linear Systems Perturbed by Bounded Disturbances **23**
3.1. Preliminaries 24
3.2. Lyapunov-based approach 26
3.2.1. Theoretical results 26
3.2.2. Output feedback 28
3.2.3. Computational aspects 33
3.2.4. Numerical examples 37
3.3. Set-based approach 42
3.3.1. State feedback 42
3.3.2. Analysis of given aperiodic schemes 43
3.3.3. Output feedback 47
3.3.4. Computational aspects 48
3.3.5. Numerical examples 53
3.4. Summary 57

4. Stochastic Threshold Design in Event-triggered Control **59**
4.1. Threshold design for arbitrarily distributed disturbances 61
4.1.1. Probability assigment 63
4.1.2. Expected value assignment 67
4.2. Stochastic thresholds for Gaußian noise disturbances 69
4.2.1. State-Feedback 70
4.2.2. Output feedback 76
4.3. Summary 78

5. Aperiodic Model Predictive Control of Constrained Linear Systems 79
5.1. Lyapunov-based approach . . . 81
5.1.1. A Lyapunov function for robust MPC . . . 81
5.1.2. Relaxing the rate of decrease . . . 82
5.1.3. Aperiodic control algorithms . . . 84
5.1.4. Implementation . . . 87
5.2. Mixed set–Lyapunov approach . . . 92
5.2.1. Feasibility by value function decrease, stability by set-membership condition . . . 92
5.2.2. Aperiodic control algorithms . . . 93
5.2.3. Implementation . . . 97
5.3. Purely set-based approach . . . 100
5.3.1. Feasibility from set-membership conditions . . . 100
5.3.2. Aperiodic control algorithms . . . 102
5.3.3. Implementation . . . 105
5.4. Threshold-based event-triggered MPC: analysis and stochastic design . . . 106
5.5. Numerical example . . . 108
5.6. Summary . . . 111

6. Output-feedback Event-triggered Model Predictive Control 113
6.1. Set-valued moving horizon estimation in model predictive control . . . 117
6.1.1. General results . . . 117
6.1.2. Realization with set-valued moving horizon estimation . . . 122
6.1.3. Implementation . . . 126
6.1.4. Numerical example . . . 127
6.2. Event-triggered output-feedback control . . . 131
6.2.1. Closed-loop properties . . . 131
6.2.2. Implementation . . . 133
6.2.3. Numerical Examples . . . 135
6.2.4. Outlook: extension to self-triggered control . . . 137
6.3. Summary . . . 138

7. Conclusions 139

A. Auxiliary Results 143

B. Proofs of Statements 149
B.1. Proof of Theorem 2.1 . . . 149
B.2. Proof of Theorem 2.3 . . . 149
B.3. Proof of Proposition 2.1 . . . 150
B.4. Proof of Lemma 3.1 . . . 151
B.5. Proof of Lemma 3.2 . . . 152

B.6. Proof of Theorem 3.5 . . . 153
B.7. Proof of Lemma 4.1 . . . 154
B.8. Proof of Lemma 4.2 . . . 154
B.9. Proof of Theorem 4.1 . . . 155
B.10.Proof of Lemma 4.3 . . . 156
B.11.Proof of Lemma 4.4 . . . 157
B.12.Proof of Theorem 4.2 . . . 159
B.13.Proof of Corollary 4.1 . . . 162
B.14.Proof of Lemma 5.1 . . . 163
B.15.Proof of Lemma 5.2 . . . 164
B.16.Proof of Proposition 5.1 . . . 165
B.17.Proof of Theorem 5.3 . . . 165
B.18.Proof of Theorem 5.5 . . . 166
B.19.Proof of Lemma 5.3 . . . 167
B.20.Proof of Lemma 5.4 . . . 168
B.21.Proof of Theorem 5.6 . . . 169
B.22.Proof of Theorem 5.8 . . . 169
B.23.Proof of Lemma 5.5 . . . 169
B.24.Proof of Theorem 5.9 . . . 171
B.25.Proof of Lemma 5.6 . . . 172
B.26.Proof of Lemma 5.7 . . . 175
B.27.Proof of Theorem 6.1 . . . 175
B.28.Proof of Lemma 6.2 . . . 176
B.29.Proof of Lemma 6.3 . . . 177
B.30.Proof of Lemma 6.4 . . . 179
B.31.Proof of Theorem 6.2 . . . 181

C. Numerical Data for the Examples in Chapter 5 **185**

Bibliography **201**