Contents

1 Introduction **1**
1.1 Motivation 1
1.2 Distributed control and estimation 3
1.3 Control of autonomous agents 6
1.4 Contribution and Outline 9

2 Distributed $\mathcal{H}_\infty$ State Estimation for Linear and Nonlinear Systems **13**
2.1 Linear Systems 14
2.1.1 Observer scheme 15
2.1.2 Centralized LMI-based solution 19
2.1.3 Distributed LMI-based solution 21
2.1.4 Relation to vector dissipativity 23
2.2 Nonlinear Systems 24
2.2.1 Observer scheme 26
2.2.2 Observer design by vector storage functions 28
2.2.3 Conservatism of the vector storage function 30
2.2.4 Extended observer design 33
2.2.5 Numerical calculation for the extended observer design 39
2.2.6 Simulation example 40
2.3 Summary and Discussion 42

3 Event-triggered Communication and Distributed Design **45**
3.1 Event-triggered Communication 46
3.1.1 Observer scheme 47
3.1.2 Observer design conditions 48
3.1.3 Exclusion of Zeno-behaviour 51
3.1.4 Simulation example 53

3.2 Dual Decomposition and Iterative optimization 55
3.2.1 Separation of the optimization problem 56
3.2.2 Iterative optimization algorithm 59
3.2.3 Simulation example 63
3.3 Self-adapting solution with Ricatti-differential equations 63
3.3.1 Simple coupling of RDEs 66
3.3.2 Information weighted coupling of RDEs 67
3.3.3 Simulation example 69
3.4 Summary and Discussion 69

4 Distributed $\mathcal{H}_\infty$ State Estimation-based Multi-Agent Coordination 73
4.1 The Synchronization Problem 74
4.1.1 Synchronization by model expansion 75
4.1.2 Synchronization by distributed reference tracking 83
4.2 Regional Estimation-based Synchronization 85
4.2.1 Regional Estimation Scheme 86
4.2.2 Proposed observer design 89
4.2.3 Robustly synchronizing controllers 93
4.2.4 Simulation example 101
4.3 Extensions of Regional Estimation-based Control 104
4.3.1 Physically interconnected agents 104
4.3.2 Unknown neighbour models 107
4.3.3 Regional estimation-based Distributed Output Regulation 115
4.4 Summary and Discussion 125

5 Conclusions 129

A Technical Preliminaries 133
A.1 Observer design 133
A.1.1 Undisturbed case 133
A.1.2 $\mathcal{L}_2$-integrable disturbances 134
A.2 Graph Theoretic Preliminaries 135

B Technical proofs 137
B.1 Proof of Theorem 4.5 137
B.2 Proof of Theorem 4.7 139
B.3 Proof of Lemma 4.5 141

B.4 Proof of Theorem 4.10 143

Bibliography **145**