

1	Introduction	1
1.1	Motivation	1
1.2	State of the Art	3
1.3	Organization	6
2	Matrix Expression of Boolean Control Networks	9
2.1	Semi-Tensor Product of Matrices	9
2.2	Properties of the Semi-Tensor Product	10
2.3	Description of Boolean Control Networks	14
2.4	Boolean Matrices	18
3	Reconstructibility analysis	21
3.1	Observability and Reconstructibility	21
3.1.1	Observability	21
3.1.2	Reconstructibility	22
3.1.3	Relationships Between Observability and Reconstructibility	23
3.2	Reconstructibility Analysis	27
3.2.1	Explicit Method	27
3.2.2	Recursive Method	30
3.2.3	Example	36
3.3	Reconstructibility for Boolean Control Networks With Unknown Inputs	39
3.3.1	Boolean Control Networks With Unknown Inputs	39
3.3.2	Decoupling the Effect of Unknown Input	41
3.3.3	Example	45
3.4	Reconstructibility of Large-scale Boolean Control Networks	46

3.4.1	Subnetworks	46
3.4.2	Reconstructibility of Large-scale Boolean Control Networks With Acyclic Structure	48
3.4.3	Reconstructibility of General Large-scale Boolean Control Networks	49
3.4.4	Example	51
4	Observer Design	55
4.1	Luenberger-like Observers	55
4.2	Unknown Input Observer	60
4.2.1	Unknown Input Estimation	62
4.2.2	Example	63
4.3	Reduced-order Observer	65
4.3.1	Concept of Reducible State Variables	66
4.3.2	Conditions on The Transformation Matrices W_σ and T_G	70
4.3.3	Recursive Algorithm to Determine Transformation Matrices	76
4.3.4	Observer Design and State Reconstruction	87
4.3.5	Observer Performance	89
4.4	Distributed Observer Design	94
5	Model-based output tracking control	99
5.1	Trackability of reference output trajectory	99
5.2	Exact tracking control	101
5.3	Optimal tracking control	103
5.3.1	Tracking error	103
5.3.2	ℓ_1 optimization problem	104
5.3.3	ℓ_∞ optimization problem	108
5.3.4	Penalty for changes in control inputs	109
5.4	Handling of constraints	113
5.4.1	State constraints	113
5.4.2	Transition constraints	114
5.4.3	Input constraints	115
5.5	Example	116
6	Model-Based Fault Diagnosis	119
6.1	Passive Fault Diagnosis	120
6.1.1	Observability Analysis	120
6.1.2	Passive Fault Detection	124

6.1.3	Passive Fault Isolation	132
6.2	Active Fault Diagnosis	144
6.2.1	Active Fault Detectability Analysis	145
6.2.2	Active Detector and Input Sequence Generator	150
6.2.3	Example	154
7	Conclusion	157
7.1	Summary	157
7.2	Future Work	159
8	Kurzfassung in deutscher Sprache (extended summary in German)	161
	Bibliography	167