

Contents

1	Introduction	1
2	State Observers for Different Types of Systems	5
2.1	Introduction	5
2.2	Full-Order State Observers for Linear Systems	8
2.2.1	Design Algorithm	12
2.2.2	A Numerical Example	12
2.3	Reduced-Order State Observers for Linear Systems	13
2.3.1	Design Algorithm	16
2.3.2	A Numerical Example	17
2.4	State Observers for Linear Systems with Unknown Inputs	18
2.4.1	Design of Full-Order Unknown Input Observers	19
2.4.2	Design Algorithm	21
2.4.3	A Numerical Example	22
2.4.4	Design of Reduced-Order Unknown Input Observers	22
2.4.5	Design Algorithm	27
2.4.6	A Numerical Example	27
2.5	Reduced-Order State Observers for Time-Delay Systems	29
2.5.1	Design Algorithm	32
2.5.2	A Numerical Example	32
2.5.3	Reduced-Order State Observers without Internal Delay	33
2.5.4	Design Algorithm	34
2.5.5	A Numerical Example	35
2.6	State Observers for Lipschitz Nonlinear Systems	36
2.6.1	Design Algorithm	40
2.6.2	A Numerical Example	40
2.7	Reduced-Order State Observers for Descriptor Systems	40
2.7.1	Design Algorithm	44
2.7.2	A Numerical Example	44
2.8	Unknown Input Observers	45
2.9	Conclusion	47

3	Linear Functional Observers	49
3.1	Introduction	49
3.2	Functional State Reconstruction Problem	50
3.3	Existence Conditions	51
3.4	Scalar Functional Observers of Order $(v - 1)$	55
3.4.1	Design Algorithm 1: Scalar Function with Order $q = (v - 1)$	56
3.4.2	A Numerical Example	57
3.5	Multi-functional Observers	58
3.5.1	Design Algorithm 2: Multiple Functions with Order $q = r$	62
3.5.2	A Numerical Example	62
3.6	An Upper Bound for the Order of Multi-functional Observers	65
3.6.1	Design Algorithm 3: Multiple Functions with Order $q = q_u$	68
3.6.2	A Numerical Example	69
3.7	Further Remarks	70
3.8	Conclusion	72
4	A Parametric Approach to the Design of Reduced-Order Linear Functional Observers	73
4.1	Introduction	73
4.2	Preliminaries	74
4.2.1	Generalized Sylvester Matrix Equation	74
4.2.2	Observable Canonical Form	76
4.3	Design of Reduced-Order Scalar Functional Observers	79
4.3.1	Design Algorithm 1: Scalar Functional Observers of Order $q < (v - 1)$	81
4.3.2	Numerical Examples	83
4.4	Extension to Linear Systems with Unknown Inputs	88
4.4.1	First-Order Functional Observers	90
4.4.2	Design Algorithm 2: First-Order Observers	92
4.4.3	A Numerical Example	93
4.4.4	Second and Higher Order Functional Observers	94
4.4.5	A Numerical Example	98
4.5	Conclusion	99
5	Functional Unknown Input Observers: Further Results and Applications	101
5.1	Introduction	101
5.2	Delay-Free Functional Observers for Time-Delay Systems	102
5.3	Observer-Based Control of Multi-Agent Systems under Decentralized Information Structure	104
5.4	Multiple Functional Unknown Input Observers	107
5.4.1	A Numerical Example	115

5.5	A Common Disturbance Decoupled Observer for Linear Systems with Unknown Inputs	116
5.5.1	A Decision Logic Switch	118
5.5.2	Construction of Ω_1	119
5.5.3	Construction of Ω_u	120
5.5.4	Existence Conditions for a Common Functional Observer	121
5.5.5	A Numerical Example	122
5.5.6	Simulation Results	123
5.6	Conclusion	126
6	Functional State and Unknown Input Observers for Nonlinear Systems	127
6.1	Introduction	127
6.2	Partial State Estimation for Nonlinear Systems	128
6.2.1	Decomposition of the Nonlinear Function	128
6.2.2	Convergence of Observer	130
6.2.3	Solvability of the Design Matrices	131
6.2.4	A Numerical Example	133
6.3	Partial State Estimation for Nonlinear Systems with Unknown Inputs	134
6.3.1	Existence Conditions and Observer Design Procedure	135
6.3.2	A Numerical Example	141
6.4	State and Input Simultaneous Estimation for Nonlinear Systems ...	142
6.4.1	Observer Design Procedure	145
6.4.2	Design Algorithm	149
6.4.3	A Numerical Example	149
6.5	Conclusion	152
7	Simultaneous State and Input Estimation	153
7.1	Introduction	153
7.2	Simultaneous Estimation of States and Unknown Inputs	153
7.2.1	Existence Conditions and an Observer Design Procedure ...	154
7.2.2	Design Algorithm: r Order Linear Functional Observer	158
7.2.3	Special Case 1	159
7.2.4	Design Algorithm: $(n + l - p)$ Order Observer	160
7.2.5	Special Case 2	161
7.2.6	A Numerical Example	163
7.3	Simultaneous State and Unknown Input Estimation for Uncertain Time-Delay Systems	164
7.3.1	Reduced-Order Observer Design	165
7.3.2	Design Algorithm	171
7.3.3	A Numerical Example	172

7.4	Simultaneous Functional State and Unknown Input Estimation	173
7.4.1	Existence Conditions and a Design Procedure	173
7.4.2	Stability Condition of $N + N_d$	178
7.4.3	Functional Observers without Internal Delays	180
7.4.4	Delay-Free Functional Observers	182
7.5	Conclusion	184
8	Further Notes on Functional Observers	185
8.1	Introduction	185
8.2	A Revisit to Linear Functional Observers for Time-Delay Systems	185
8.2.1	Design Algorithm	192
8.2.2	A Numerical Example	192
8.3	Delayed Output Information	193
8.3.1	Design Algorithm	197
8.3.2	A Numerical Example	198
8.3.3	Further Notes and Open Problems	198
8.4	Interconnected Systems	200
8.5	Conclusion	204
	References	205
	Index	213