

Contents

Preface	V
List of Figures	XIII
List of Tables	XV
List of Notations	XVII
1 Introduction	1
1.1 Motivation of the Work	1
1.2 Objectives of the Work	6
1.3 Outline of the Thesis	7
2 Overview of FD and FTC Technology	11
2.1 FD and FTC Configuration for LTI Systems	11
2.1.1 Coprime Factorization Techniques	12
2.1.2 The Configuration of Observer-based FD Systems	13
2.1.3 The Configuration of Observer-based FTC	16
2.2 FDI and FTC Schemes for Nonlinear Systems	20
2.2.1 Representation of Nonlinear Systems	20
2.2.2 Classification of Observer-based FDI Techniques .	22
2.2.3 Classification of FTC Techniques for Nonlinear Systems	25
2.3 Concluding Remarks	27
3 Configuration of Nonlinear Observer-based FD Systems	29
3.1 Preliminaries and Problem Formulation	30
3.2 On the Existence Conditions of Observer-based FD Systems	31
3.2.1 $\mathcal{L}_\infty$ Observer-based FD Systems	33
3.2.2 $\mathcal{L}_2$ Observer-based FD Systems	35
3.2.3 $\mathcal{L}_\infty/\mathcal{L}_2$ Observer-based FD Systems	36

3.3	Parametrization of Nonlinear Residual Generators	39
3.4	Parametrization of Nonlinear FD Systems	43
3.4.1	$\mathcal{L}_\infty$ -Class FD Systems	45
3.4.2	$\mathcal{L}_2$ -Class FD System	47
3.5	Numerical Examples	49
3.6	Concluding Remarks	53
4	Design of $\mathcal{L}_2$ Nonlinear Observer-based FD Systems	55
4.1	Preliminaries and Problem Formulation	55
4.2	Design of $\mathcal{L}_2$ Fuzzy Observer-based FD Systems	56
4.2.1	Fuzzy Dynamic Modelling	56
4.2.2	$\mathcal{L}_2$ Fuzzy Observer-based Residual Generator . . .	58
4.2.3	$\mathcal{L}_2$ Fuzzy Observer-based FD Systems	63
4.3	Design of $\mathcal{L}_2$ Robust Fuzzy Observer-based FD Systems .	64
4.4	A Numerical Example	67
4.5	Concluding Remarks	68
5	Design of $\mathcal{L}_\infty/\mathcal{L}_2$ Nonlinear Observer-based FD Systems	69
5.1	Preliminaries and Problem Formulation	70
5.2	Design of $\mathcal{L}_\infty/\mathcal{L}_2$ Type of Fuzzy Observer-based FD Systems	71
5.2.1	Fuzzy Dynamic Modelling	71
5.2.2	$\mathcal{L}_\infty/\mathcal{L}_2$ Type of Fuzzy Observer-based Residual Generator	74
5.2.3	$\mathcal{L}_\infty/\mathcal{L}_2$ Type of Fuzzy Observer-based FD Systems	85
5.3	A Numerical Example	86
5.4	Concluding Remarks	87
6	Design of Weighted Fuzzy Observer-based FD Systems	89
6.1	Preliminaries and Problem Formulation	90
6.1.1	Configuration of Discrete-Time $\mathcal{L}_2$ Observer-based FD Systems	90
6.1.2	The Existence Condition of Discrete-Time $\mathcal{L}_2$ Observer-based FD Systems	91
6.1.3	FD Performance	93
6.1.4	Problem Formulation	94
6.2	$\mathcal{L}_2$ Piecewise-Fuzzy Observer-based FD Systems	94
6.2.1	Piecewise-Fuzzy Dynamic Modelling	95
6.2.2	Weighted Piecewise-Fuzzy Residual Generator . .	97
6.2.3	An Integrated Design Scheme of FD Systems . . .	100

6.3	$\mathcal{L}_2$ Robust Piecewise-Fuzzy Observer-based FD Systems .	107
6.4	A Numerical Example	111
6.5	Concluding Remarks	114
7	FTC Configurations for Nonlinear Systems	115
7.1	Preliminaries and Problem Formulation	116
7.2	Residual Generator-based FTC Configurations	116
7.2.1	Controller Parametrization	117
7.2.2	Residual Generator-based Realizations of Con- troller Parameterization	119
7.2.3	FTC Configurations	124
7.3	A Design Scheme of FTC Configuration	126
7.3.1	Observer-based Fault Diagnosis System Design . .	127
7.3.2	Controller Design	129
7.4	A Numerical Example	131
7.5	Concluding Remarks	134
8	Application to Benchmark Processes	135
8.1	Case Studies on CSTD Process	135
8.1.1	Process Description	135
8.1.2	$\mathcal{L}_2$ Fuzzy Observer-based FD for Continuous Non- linear Systems	139
8.1.3	Weighted $\mathcal{L}_2$ Fuzzy Observer-based FD for Discrete-Time Nonlinear Systems	144
8.2	Case Studies on Three-Tank System	148
8.2.1	Process Description	149
8.2.2	Real-Time Implementation of FTC Architecture with Embedded Runge-Kutta Iterations	150
8.2.3	$\mathcal{L}_\infty/\mathcal{L}_2$ Fuzzy Observer-based FD	156
8.3	Concluding Remarks	160
9	Conclusions and Future Work	161
	Bibliography	163