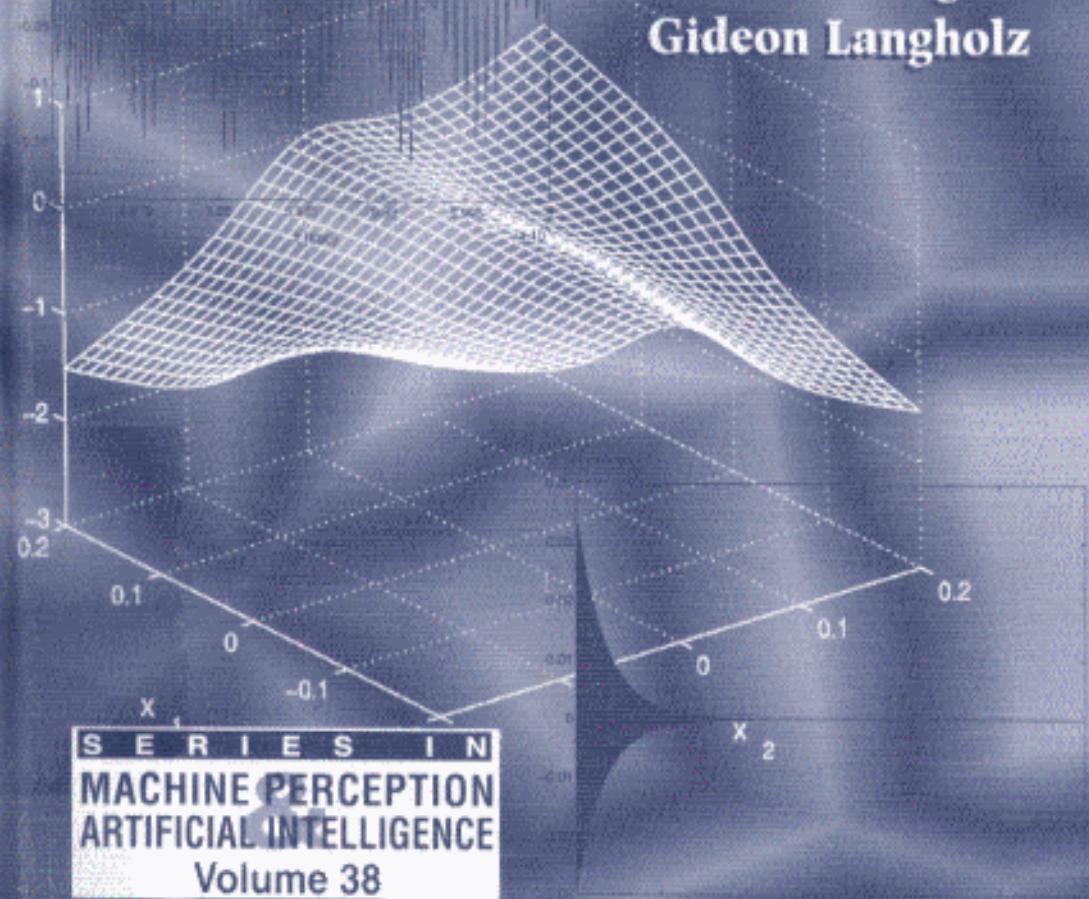


NEW APPROACHES TO FUZZY MODELING AND CONTROL DESIGN AND ANALYSIS

Michael Margaliot
Gideon Langholz



SERIES IN
MACHINE PERCEPTION
ARTIFICIAL INTELLIGENCE
Volume 38

World Scientific

Contents

Preface	vii
Chapter 1 Prologue	1
1.1 Background	1
1.2 Preview	8
1.2.1 Fuzzy Lyapunov synthesis	9
1.2.2 Hyperbolic optimal control	12
1.3 Notes and References	15
Chapter 2 Fuzzy Lyapunov Synthesis	17
2.1 Introduction	17
2.2 The Design Method	19
2.3 Putting it to Work: Design Examples	20
2.3.1 Stabilizing the inverted pendulum	20
2.3.2 Inverted pendulum tracking	23
2.3.3 Designing a fuzzy PID controller	26
2.3.4 Designing a dynamic fuzzy scheduler	29
2.3.5 Designing a TS-type fuzzy controller	38
2.4 Summary and Discussion	44
2.5 Notes and References	45
Chapter 3 Fuzzy Lyapunov Synthesis and Stability Analysis	47
3.1 Introduction	47
3.2 Classical Lyapunov Stability Analysis	48
3.3 Fuzzy Lyapunov Stability Analysis	53

3.4	Summary and Discussion	56
3.5	Notes and References	57
Chapter 4 Adaptive Fuzzy Controller Design		59
4.1	Introduction	59
4.2	Designing the Rule-Base	61
4.3	Adaptation	61
4.4	Example: Inverted Pendulum Control	63
4.4.1	Designing the controller's rule-base	65
4.4.2	Adapting the controller	69
4.5	Summary and Discussion	71
4.6	Notes and References	71
Chapter 5 Inverse Optimality for Fuzzy Controllers		73
5.1	Introduction	73
5.2	Review of Optimality and Inverse Optimality	74
5.2.1	Stability and robustness of optimal controllers	76
5.3	The Scalar Case	78
5.4	<i>N</i> -th Order Systems	82
5.5	Stability	88
5.6	Robustness	89
5.7	Summary and Discussion	92
5.8	Notes and References	94
5.9	Appendix	94
Chapter 6 Hyperbolic Approach to Fuzzy Modeling		103
6.1	Introduction	103
6.2	The Hyperbolic State-Space Model	105
6.3	Approximation Capabilities	106
6.4	The Modeling Process	108
6.5	On-Line Parameter Estimation	113
6.6	Summary and Discussion	126
6.7	Notes and References	126
Chapter 7 Fuzzy Controllers for the Hyperbolic State-Space Model		127
7.1	Introduction	127
7.2	Diagonal Stabilization	128

7.3	Nonlinear H_2 Optimal Control	132
7.4	Nonlinear H_∞ Optimal Control	136
7.5	Linguistic Interpretation	143
7.5.1	Comparing the diagonally stabilizing and H_2 controllers	144
7.5.2	Fuzzy game strategies	145
7.5.3	Fuzzy Lyapunov stability analysis	147
7.6	Summary and Discussion	149
7.7	Notes and References	150
Chapter 8 Epilogue		151
Appendix A Mathematical Background		153
A.1	Introduction	153
A.2	The Lipschitz Condition	154
A.3	Lyapunov Stability	156
A.4	Passivity	161
A.5	Optimal Control via the HJB Equation	165
A.6	Optimal Control via Circuit Analysis	167
A.6.1	Linear passivity and optimality	167
A.6.2	Nonlinear passivity and optimality	170
A.7	The Integral-Invariance Principle	174
A.8	Notes and References	176
References		177
Index		183