

Table of Contents

Preface	V
Acknowledgements	VII
1. Introduction	1
1.1 Background	2
1.1.1 Adaptive Control and Optimal Control	2
1.1.2 Control of Systems with Nonsmooth Nonlinearities ...	4
1.1.3 Neural Networks	6
1.2 Research Motivation	7
1.3 Monograph Outline	8
2. Problem Formulation	9
2.1 Sandwich System Examples	9
2.1.1 System with a Sandwiched Dead-Zone	9
2.1.2 System with Sandwiched Backlash	13
2.1.3 System with Sandwiched Hysteresis	14
2.1.4 System with Sandwiched Friction	14
2.2 Research Objectives	15
3. Continuous-Time Control Designs	17
3.1 Control Designs	17
3.2 Simulations and Analysis	19
3.3 Describing Function Analysis	20
3.4 Dead-Zone Compensation	22
3.5 Discussion	28
4. Hybrid Control Designs	29
4.1 Hybrid Control with $x(t)$ measured	30
4.1.1 Controller Structure	30
4.1.2 System Analysis using Describing Functions	37
4.2 Performance Analysis	38
4.2.1 Inter-sampling Dynamics	39
4.2.2 Stability and Tracking Performance	40
4.2.3 Compensation for Other Sandwiched Nonlinearities ...	45

4.3	Control Scheme with $u(t)$ Measured	46
4.4	An Illustrative Example	49
4.5	Conclusions	53
5.	Adaptive Inverse Hybrid Design	55
5.1	Adaptive Inverse Design	55
5.1.1	Parametrization of Dead-Zone and Dead-Zone Inverse	56
5.1.2	Control Error	58
5.1.3	Inter-sampling dynamics: effect on control error	58
5.1.4	Simplified control error expression	61
5.2	Tracking Error and Stability Analysis	62
5.2.1	Adaptive Update Law	65
5.2.2	Stability	68
5.2.3	σ -Modification with Parameter Projection	71
5.3	A Case Study	73
5.4	Conclusions	75
6.	Neural Hybrid Control	77
6.1	Background	77
6.1.1	Neural Network Theory	78
6.1.2	NN Approximation of Jump Nonlinearities	79
6.1.3	NN based Dead-Zone Precompensator	80
6.2	Neural-Hybrid Controller	81
6.2.1	Controller Structure	81
6.2.2	Control Error	86
6.2.3	Analysis for Modeling Mismatch $d(t)$	90
6.2.4	Closed-Loop Error Dynamics and Tuning Laws	91
6.2.5	Stability Analysis of the Tuning Laws	94
6.3	Simulation Study	98
6.4	Conclusions	100
7.	Friction Compensation for A Sandwich Dynamic System	103
7.1	The Benchmark System and Control Problems	104
7.2	State Feedback MRAC for Output Tracking	107
7.3	Friction Compensation	110
7.3.1	Friction Model	110
7.3.2	Friction Compensator Structure	111
7.3.3	Output Matching Conditions	113
7.3.4	Adaptive Friction Compensation	114
7.4	Simulation Study	123
7.5	Conclusions	125

8. Adaptive Friction Compensation Based on Feedback	
Linearization	127
8.1 Preliminaries	128
8.1.1 Feedback Linearization	128
8.1.2 Adaptive control of Linearizable Systems	130
8.2 A Sandwich Nonlinear System with Friction	132
8.2.1 System Model	132
8.2.2 Problem Statement	134
8.3 Designs without Friction	135
8.3.1 Case 1: Feedback Linearizing Control for Known Sys- tem Dynamics	135
8.3.2 Case 2: Adaptive Feedback Linearizing Control for Un- known System Dynamics	138
8.4 Friction Compensation Control	140
8.4.1 Cases 3 and 4: Known Friction Model	141
8.4.2 Cases 5 and 6: Unknown Friction Model	144
8.5 Conclusions	148
9. Control of Systems with Actuator Nonlinearities and	
Failures	149
9.1 Problem Statement	150
9.1.1 Actuator Nonlinearity and Inversion	151
9.1.2 Control Objectives	153
9.2 State Tracking Compensation Control	154
9.2.1 Basic Matching Conditions	154
9.2.2 Actuator Nonlinearity and Failure Compensation	156
9.2.3 Adaptive State Tracking Control Design	157
9.2.4 Simulation Results	160
9.3 Output Tracking Compensation Control	162
9.3.1 Plant-Model Output Matching	164
9.3.2 Adaptive Output Tracking Control Design	166
9.3.3 Simulation Results	169
9.4 Compensation Control for Sandwich Systems	171
9.4.1 A Nominal Controller Structure	173
9.4.2 A Hybrid Control Design	176
9.4.3 An Adaptive Control Design	180
9.5 Conclusions	184
10. Control of Systems with Sandwiched Backlash	185
10.1 Introduction	185
10.2 System Model and Control Problems	187
10.2.1 System Model	187
10.2.2 Control Problems	189

10.3 Turret and Barrel Backlash Compensation 190

 10.3.1 An Optimal Control Design 190

 10.3.2 An Alternative Optimal Control Design 193

10.4 Turret Backlash Compensation Control 194

 10.4.1 Problem Statement 194

 10.4.2 Feedback Control 195

 10.4.3 Backlash Compensation 200

10.5 Barrel Backlash Compensation Control 202

10.6 Feedback Control for Flexibility and Damping 203

10.7 Generalization and Performance 208

 10.7.1 Multi-Input and Multi-Output Cases 208

 10.7.2 Simulation Results 210

10.8 Concluding Remarks 214

11. Conclusions and Future Research 215

 11.1 Summary 215

 11.2 Future Topics 217

References 219

Index 225

<http://www.springer.com/978-3-540-44115-1>

Control of Sandwich Nonlinear Systems

Taware, A.; Tao, G.

2003, XII, 226 p. 45 illus., Softcover

ISBN: 978-3-540-44115-1