

Contents

Preface	v
Notation	xi
1 Introduction	1
1.1 Limited data rate	2
1.2 Outline and contributions	3
2 Control networks	7
2.1 Control over networks	7
2.2 How control networks work	8
2.2.1 Periodic pattern	8
2.2.2 Medium access methods	9
2.2.3 A protocol example	10
2.3 Application examples	12
2.3.1 Jacking systems of train cars	12
2.3.2 Networks on automobiles	13
2.3.3 Process control	14
3 Distributed control over networks	15
3.1 The switch box problem	15
3.2 Preliminaries	17
3.3 Stabilization using PTV local controllers	19
3.4 Assignability measure analysis	23
3.5 Multiple mobile robot example	25
4 Finite data rate control — single-input case	33
4.1 Dwell-time switched systems and their stability	33
4.2 Quadratic stabilization of sampled-data systems	35
4.2.1 Problem formulation	35
4.2.2 Control Lyapunov function approach	37
4.2.3 Bounds on trajectories	40
4.2.4 Solution to the sampled-data problem	42

4.3	Quantized sampled-data control	47
4.3.1	Problem formulation	48
4.3.2	A sufficient condition for stability	49
4.3.3	Solution to the quantized sampled-data problem	51
4.4	Finite quantizers	60
4.5	Control over a finite data rate channel	63
4.5.1	Data rate for control	63
4.5.2	Time delay analysis	64
4.5.3	Time delay and quantization	68
4.6	Design of σ	70
4.7	Magnetic ball levitation example	72
5	Towards data rate reduction	83
5.1	Time-varying quantization	83
5.1.1	Problem formulation	83
5.1.2	A switching law	85
5.1.3	Magnetic ball levitation example continued	88
5.2	Nonuniform sampling	89
5.3	Dwell-time switching control	90
5.3.1	Dwell-time switched systems with logarithmic partitions	91
5.3.2	Problem formulation	93
5.3.3	Hybrid automata representation	94
5.3.4	Solution to the dwell-time switching problem	98
5.4	Finite partition dwell-time switching	101
5.4.1	Dwell-time switched systems with finite partitions	102
5.4.2	State feedback control	103
5.4.3	State feedback under measurement noise	104
5.4.4	Observer-based output feedback	106
5.4.5	Cart-pendulum system example	109
6	Extensions for the multiple input case	117
6.1	Quadratic stabilization of sampled-data systems	117
6.1.1	Problem formulation	117
6.1.2	Generalization of the setup	119
6.1.3	Bounds on trajectories	122
6.1.4	Solution to the sampled-data problem	125
6.2	Quantized sampled-data control	128
6.2.1	Problem formulation	128
6.2.2	Solution to the quantized sampled-data problem	129
6.3	Dwell-time switching control	140
6.3.1	Dwell-time switched systems with logarithmic partitions	140
6.3.2	Problem formulation	143
6.3.3	Solution to the dwell-time switching problem	144

6.4	Design of S	147
6.4.1	A sufficient condition for $S > I$	148
6.4.2	Extension of the design method for σ	149
6.4.3	A design method for $S > I$	150
6.5	Two cart-pendulum system example	152
7	Conclusion	161
Bibliography		163
Symbol Index		170
Subject Index		172