

Contents

1	Introduction	1
1.1	What Is Cooperative Control?	1
1.2	What Is in This Book?	4
1.3	Notation and Definition	6
1.4	Basic Graph Theory	8
1.5	Passivity and Passivity-preserving Structures	13
2	Passivity As a Design Tool for Cooperative Control	19
2.1	Introduction	19
2.2	Problem Statement	19
2.3	The Passivity-based Design Procedure	21
2.4	Stability Results	24
2.5	Application to the Agreement Problem	28
2.6	Position-based Formation Control As a Shifted Agreement Problem	29
2.6.1	Design Example	31
2.6.2	A Simulation Example	34
2.7	Distance-based Formation Control	36
2.7.1	Passivity-based Design	36
2.7.2	Existence and Uniqueness of a Formation Shape	42
2.8	Distance-based or Position-based?	44
2.9	Summary	48
2.10	Notes and Related Literature	48
3	Adaptive Design for Reference Velocity Recovery: Internal Model Approach	51
3.1	Introduction	51
3.2	Why Adaptation?	52
3.3	Internal Model Approach: The <i>Basic</i> Design	53
3.4	Design Examples for Distance-based Formation Control	60
3.4.1	Constant Reference Velocity	60
3.4.2	Motivating Example for the Augmented Design	61

3.5	The <i>Augmented</i> Design	63
3.5.1	Motivating Example Revisited	66
3.6	When There Is No Leader	67
4	Adaptive Design for Reference Velocity Recovery: Parameterization	
	Approach	71
4.1	Introduction	71
4.2	The Basic Design	73
4.3	Parameter Convergence	75
4.4	The <i>Augmented</i> Design	78
4.5	Application to Gradient Climbing in Formation	81
4.5.1	Reference Velocity Assignment by the Leader	83
4.5.2	Gradient Climbing in Formation	87
4.5.3	Simulation Results	88
4.6	Summary	89
4.7	Notes	90
5	Attitude Coordination Without Inertial Frame Information	93
5.1	Introduction	93
5.2	Kinematic Equation of Attitude Error	94
5.3	Passivity-based Group Attitude Agreement	95
5.4	Other Representations of $SO(3)$	99
5.5	Attitude Coordination in the Plane	101
5.6	Adaptive Design for Reference Angular Velocity Recovery	103
5.7	Simulation Results	104
5.7.1	Nonadaptive Design	104
5.7.2	Adaptive Design	105
5.8	Summary	106
5.9	Related Literature	107
6	The Agreement of Euler-Lagrange Systems	109
6.1	Introduction	109
6.2	The Nominal System	110
6.3	The Uncertain System	112
6.4	A Preliminary Adaptive Design	115
6.5	Design 1: Adding a Cross Term	117
6.6	Design 2: Feedforward of the External Feedback	122
6.7	Summary	129
7	Synchronized Path Following	131
7.1	Introduction	131
7.2	Path-following Design and Synchronization	132
7.3	Passivity-based Designs for Synchronization	133
7.3.1	Design 1: Without Path Error Feedback	133
7.3.2	Design 2: With Path Error Feedback	134
7.4	Design Example	138

7.4.1	Agent Dynamics	138
7.4.2	Trajectory Generation	139
7.4.3	Preliminary Backstepping Design	140
7.4.4	Adaptive Design to Estimate Reference Velocity	142
7.4.5	Saturation in Thrust	143
7.5	Summary	145
7.6	Notes	146
8	Cooperative Load Transport	147
8.1	Introduction	147
8.2	Problem Formulation	148
8.3	Decentralized Control With Reference Velocity	150
8.4	Decentralized Control Without Reference Velocity	152
8.5	Experiments	154
8.5.1	Hardware	154
8.5.2	Implementation	154
8.6	Summary	158
8.7	Notes	159
9	Caveats for Robustness	165
9.1	Introduction	165
9.2	Instability due to Switching Topology	166
9.2.1	Example	166
9.2.2	Comparison with First-order Agent Models	167
9.2.3	When is Stability Maintained?	169
9.3	Parametric Resonance	170
9.3.1	Example	170
9.3.2	Coupled Mathieu Equations	172
9.3.3	Fast Varying Perturbation	173
9.3.4	Slowly Varying Perturbation	174
9.4	Unmodeled Dynamics	175
9.5	Summary	177
A	Proofs	179
A.1	Proof of Corollary 3.2	179
A.2	Proof of Corollary 3.3	180
A.3	Proof of Lemma 4.2	180
A.4	Proof of Theorem 5.2	182
A.5	Proof of Proposition 8.1	184
A.6	Proof of Proposition 8.2	185
A.7	Proof of Corollary 8.3	186
A.8	Proof of Theorem 9.1	186

B	Technical Tools Used in the Book	189
B.1	Schur Decomposition	189
B.2	Invariance Principle [69, Theorem 4.4]	189
B.3	Barbalat's Lemma	190
B.4	Proposition 2.44 in [119]	190
B.5	Nested Matrosov Theorem [85, Theorem 1]	191
B.6	Lemma 4.7 in [69]	191
B.7	Theorem 4.19 in [69]	192
B.8	Proposition 2 in [65]	192
B.9	Theorem 10.4 in [69]	192
B.10	Theorem 3.4.11 in [62]	193
B.11	Summary of Example 11.14 in [69]	193
B.12	Rigid Body Attitude and Its Parameterizations	194
	B.12.1 Rigid Body Attitude	194
	B.12.2 Parameterizations of Attitude Matrix	195
B.13	Rigid Body Kinematics	197
B.14	Rigid Body Dynamics	199
Index		201
	References	203



<http://www.springer.com/978-1-4614-0013-4>

Cooperative Control Design
A Systematic, Passivity-Based Approach
Bai, H.; Arcak, M.; Wen, J.
2011, XIV, 210 p., Hardcover
ISBN: 978-1-4614-0013-4