

Table of Contents

Abstract	ix
Deutsche Kurzfassung	xi
1 Introduction	1
1.1 Motivation and Focus	1
1.2 Contributions and Organization	3
2 Polyhedral Approximation Methods for Cooperative Optimization	11
2.1 Introduction	11
2.2 Distributed Algorithms in Peer-to-Peer Networks	14
2.2.1 Communication Network Model	14
2.2.2 Distributed Algorithms	15
2.2.3 Complexity Notions	16
2.3 The Cutting-Plane Consensus Algorithm	17
2.3.1 General Problem Formulation	18
2.3.2 Unique Solution Linear Programming	20
2.3.3 The Algorithm Definition	26
2.3.4 Technical Analysis	27
2.4 Convex Inequality Constraints	32
2.4.1 Problem Formulation	32
2.4.2 Semidefinite Constraints	33
2.4.3 Linear Constraints	34
2.4.4 Application Example: Position Estimation in Wireless Sensor Networks	36
2.5 Robust Optimization with Uncertain Constraints	38
2.5.1 Problem Formulation	38
2.5.2 Efficiently Solvable Problems	40
2.5.3 Computational Study: Robust Linear Programming	41
2.6 Conclusions	43
3 Dual Cutting-Plane and Trajectory Exchange Optimization	45
3.1 Introduction	45
3.2 A Motivating Problem: Distributed Cooperative Model Predictive Control	46
3.2.1 Problem Formulation	46
3.2.2 Dual Semi-Infinite Problem Representation	48
3.3 Revisiting the Richards and How Algorithm	49
3.4 Distributed Nonlinear Dantzig-Wolfe Decomposition	53
3.4.1 Distributed Constraint Generation	53
3.4.2 Linear Programming Dual Interpretation	55
3.4.3 CPC-based Trajectory Exchange Method	58

3.5	Application Example: Distributed Microgrid Control	59
3.6	Conclusions	63
4	Duality and Network Theory in Cooperative Control	65
4.1	Introduction	65
4.2	Preliminaries	67
4.2.1	Algebraic Graph Theory	67
4.2.2	Network Theory	70
4.2.3	Equilibrium Independent Passivity	72
4.3	Duality in Passivity-based Cooperative Control	75
4.3.1	The Plant Level	77
4.3.2	The Control Level	80
4.3.3	The Closed-Loop Perspective	82
4.4	Application Example: Optimal Distribution Control	85
4.5	Conclusions	87
5	Clustering in Dynamical Networks	89
5.1	Introduction	89
5.2	Constrained Flows & Network Clustering	91
5.2.1	A Primal/Dual and Saddle-Point Perspective	91
5.2.2	Saddle-Point Problem and Network Clustering	93
5.3	Clustering in Dynamical Networks	95
5.3.1	A Dynamical Model for Clustering	96
5.3.2	Clustering Analysis and Convergence	98
5.3.3	Application Examples	100
5.4	Hierarchical Clustering Using a Saddle-Point Analysis	106
5.4.1	Combinatorial Conditions for Clustering	106
5.4.2	A Hierarchical Clustering Algorithm	109
5.4.3	Application Example: Structural Analysis of Power Networks	111
5.5	Conclusions	114
6	Conclusions and Outlook	117
6.1	Conclusions	117
6.2	Outlook	119
A	Convex Analysis and Optimization Theory	121
B	Dynamical Systems and Control Theory	127
C	Graph Theory	131
	Bibliography	135