
Contents

Preface	ix
PART I. ROBUST LINEAR OPTIMIZATION	1
Chapter 1. Uncertain Linear Optimization Problems and their Robust Counterparts	3
1.1 Data Uncertainty in Linear Optimization	3
1.2 Uncertain Linear Problems and their Robust Counterparts	7
1.3 Tractability of Robust Counterparts	16
1.4 Non-Affine Perturbations	23
1.5 Exercises	25
1.6 Notes and Remarks	25
Chapter 2. Robust Counterpart Approximations of Scalar Chance Constraints	27
2.1 How to Specify an Uncertainty Set	27
2.2 Chance Constraints and their Safe Tractable Approximations	28
2.3 Safe Tractable Approximations of Scalar Chance Constraints: Basic Examples	31
2.4 Extensions	44
2.5 Exercises	60
2.6 Notes and Remarks	64
Chapter 3. Globalized Robust Counterparts of Uncertain LO Problems	67
3.1 Globalized Robust Counterpart — Motivation and Definition	67
3.2 Computational Tractability of GRC	69
3.3 Example: Synthesis of Antenna Arrays	70
3.4 Exercises	79
3.5 Notes and Remarks	79
Chapter 4. More on Safe Tractable Approximations of Scalar Chance Constraints	81

4.1	Robust Counterpart Representation of a Safe Convex Approximation to a Scalar Chance Constraint	81
4.2	Bernstein Approximation of a Chance Constraint	83
4.3	From Bernstein Approximation to Conditional Value at Risk and Back	90
4.4	Majorization	105
4.5	Beyond the Case of Independent Linear Perturbations	109
4.6	Exercises	136
4.7	Notes and Remarks	145
PART II. ROBUST CONIC OPTIMIZATION		147
Chapter 5. Uncertain Conic Optimization: The Concepts		149
5.1	Uncertain Conic Optimization: Preliminaries	149
5.2	Robust Counterpart of Uncertain Conic Problem: Tractability	151
5.3	Safe Tractable Approximations of RCs of Uncertain Conic Inequalities	153
5.4	Exercises	156
5.5	Notes and Remarks	157
Chapter 6. Uncertain Conic Quadratic Problems with Tractable RCs		159
6.1	A Generic Solvable Case: Scenario Uncertainty	159
6.2	Solvable Case I: Simple Interval Uncertainty	160
6.3	Solvable Case II: Unstructured Norm-Bounded Uncertainty	161
6.4	Solvable Case III: Convex Quadratic Inequality with Unstructured Norm-Bounded Uncertainty	165
6.5	Solvable Case IV: CQI with Simple Ellipsoidal Uncertainty	167
6.6	Illustration: Robust Linear Estimation	173
6.7	Exercises	178
6.8	Notes and Remarks	178
Chapter 7. Approximating RCs of Uncertain Conic Quadratic Problems		179
7.1	Structured Norm-Bounded Uncertainty	179
7.2	The Case of \cap -Ellipsoidal Uncertainty	195
7.3	Exercises	201
7.4	Notes and Remarks	201
Chapter 8. Uncertain Semidefinite Problems with Tractable RCs		203
8.1	Uncertain Semidefinite Problems	203
8.2	Tractability of RCs of Uncertain Semidefinite Problems	204
8.3	Exercises	222

8.4	Notes and Remarks	222
Chapter 9. Approximating RCs of Uncertain Semidefinite Problems		225
9.1	Tight Tractable Approximations of RCs of Uncertain SDPs with Structured Norm-Bounded Uncertainty	225
9.2	Exercises	232
9.3	Notes and Remarks	234
Chapter 10. Approximating Chance Constrained CQIs and LMIs		235
10.1	Chance Constrained LMIs	235
10.2	The Approximation Scheme	240
10.3	Gaussian Majorization	252
10.4	Chance Constrained LMIs: Special Cases	255
10.5	Notes and Remarks	276
Chapter 11. Globalized Robust Counterparts of Uncertain Conic Problems		279
11.1	Globalized Robust Counterparts of Uncertain Conic Problems: Definition	279
11.2	Safe Tractable Approximations of GRCs	281
11.3	GRC of Uncertain Constraint: Decomposition	282
11.4	Tractability of GRCs	284
11.5	Illustration: Robust Analysis of Nonexpansive Dynamical Systems	292
Chapter 12. Robust Classification and Estimation		301
12.1	Robust Support Vector Machines	301
12.2	Robust Classification and Regression	309
12.3	Affine Uncertainty Models	325
12.4	Random Affine Uncertainty Models	331
12.5	Exercises	336
12.6	Notes and remarks	337
PART III. ROBUST MULTI-STAGE OPTIMIZATION		339
Chapter 13. Robust Markov Decision Processes		341
13.1	Markov Decision Processes	341
13.2	The Robust MDP Problems	345
13.3	The Robust Bellman Recursion on Finite Horizon	347
13.4	Notes and Remarks	352
Chapter 14. Robust Adjustable Multistage Optimization		355

14.1	Adjustable Robust Optimization: Motivation	355
14.2	Adjustable Robust Counterpart	357
14.3	Affinely Adjustable Robust Counterparts	368
14.4	Adjustable Robust Optimization and Synthesis of Linear Controllers	392
14.5	Exercises	408
14.6	Notes and Remarks	411
PART IV. SELECTED APPLICATIONS		415
Chapter 15. Selected Applications		417
15.1	Robust Linear Regression and Manufacturing of TV Tubes	417
15.2	Inventory Management with Flexible Commitment Contracts	421
15.3	Controlling a Multi-Echelon Multi-Period Supply Chain	432
Appendix A. Notation and Prerequisites		447
A.1	Notation	447
A.2	Conic Programming	448
A.3	Efficient Solvability of Convex Programming	460
Appendix B. Some Auxiliary Proofs		469
B.1	Proofs for Chapter 4	469
B.2	\mathcal{S} -Lemma	481
B.3	Approximate \mathcal{S} -Lemma	483
B.4	Matrix Cube Theorem	489
B.5	Proofs for Chapter 10	506
Appendix C. Solutions to Selected Exercises		511
C.1	Chapter 1	511
C.2	Chapter 2	511
C.3	Chapter 3	513
C.4	Chapter 4	513
C.5	Chapter 5	516
C.6	Chapter 6	519
C.7	Chapter 7	520
C.8	Chapter 8	521
C.9	Chapter 9	523
C.10	Chapter 12	525
C.11	Chapter 14	527
Bibliography		531
Index		539