## Contents

Preface			ix	
Table of notation				
1	Some results from convex analysis			
•	1.1	Introduction	1	
	1.2	Convex sets	2	
	1.3	Theorems of the alternative	9	
	1.4	Convex functions	12	
	1.5	Optimality conditions	22	
	1.6	Conjugate convex functions, duality	30	
	1.7	Descent methods for minimizing convex functions	38	
	1.,	Notes on Chapter 1	45	
2	Line	ar programming	46	
2	2.1	Introduction	46	
	2.2		47	
		Algebraic theory	54	
	2.4	The simplex algorithm	57	
	2.5	The reduced gradient algorithm for LP1	77	
	2.6	The projected gradient algorithm for LP1	94	
	2.7	Interval programming	107	
	2.8	A penalty function method	115	
	2.0	Notes on Chapter 2	124	
3	Δpr	olications of linear programming in discrete approxima-		
3	Th	tion	128	
	3.1	Introduction	128	
	3.2	Descent methods for la approximation	137	
	3.3	1 there in 1 opprovimation	151	
	3.4	Descent algorithm for the l <sub>m</sub> problem	154	
	3.5	Ascent algorithms for the discrete approximation	157	
		problem	170	
	3.6	" I lalaman	178	

vi CONTENTS

4	Poly	hedral convex functions	181
		Introduction	181
	4.2	Subdifferential structure of polyhedral convex functions	191
		Uniqueness questions for the minima of polyhedral	
		convex functions	199
	4.4	Descent methods for minimizing polyhedral convex	
		functions	200
	4.5	Continuation and the projected gradient algorithm	210
		Notes on Chapter 4	212
5	Least squares and related methods		
	5.1	Introduction	214
	5.2	Least squares methods	215
	5.3	-	229
	5.4		250
	5.5	Sensitivity of estimation procedures	259
	5.6	Algorithms for M-estimation	268
		Notes on Chapter 5	283
6	Some applications to non-convex problems		
	6.1	Introduction	286
	6.2		289
	6.3	The total approximation problem in separable norms	297
	6.4	The total $l_1$ problem	305
	6.5	Finding centres in the Jaccard metric	313
		Notes on Chapter 6	318
7	Some questions of complexity and performance		
	7.1		319
	7.2		321
	7.3		324
	7.4	Determining expected behaviour	332
	7.5	Some implementation considerations	341
		Notes on Chapter 7	347
Appe	ndix 1		348
	A1.1	Notation	348
	A1.2		349
	A1.3	Matrix factorizations based on elementary matrices	353
		Notes on Appendix 1	355
Appe	ndix 2		356
	A2.1	Introduction	356
	A2.2	The $L_1$ approximation problem	356

	CONTENTS	vii
A2.3	Approximation in the maximum norm Notes on Appendix 2	359 365
References		366
Index		373