Contents

Aut	hors an	d Contributors	viii
Pre	face		ix
Ac	knowled	gements	xi
Ou	tline and	d Roadmap	xiii
1	Overv	iew	1
	1.1 Sub 1.2 Cha 1.3 Loca 1.4 Mat 1.5 Dyn	surface Imaging: Scope and Applications Illenges of Subsurface Imaging alized and Tomographic Imaging hematics of Subsurface Imaging amic, Multispectral, Multisensor, and Multiwave Imaging	2 5 10 13 16
2	Physic	cal Models	21
	2.1 Way 2.2 Way 2.3 Way 2.4 Con 2.5 Sou Furt Prol	res: Electromagnetic and Acoustic re Interaction I re Interaction II strast Agents rces and Detectors ther Reading blems	22 37 58 68 73 81 83
3	Locali	zed Imaging	85
	3.1 Two 3.2 Thre 3.3 Ima Furt Prol	-Dimensional Imaging se-Dimensional Imaging ge Restoration ther Reading blems	87 108 131 135 136
4	Tomog	graphic Imaging	139
	4.1 Ray 4.2 Ran 4.3 Way 4.4 Spe 4.5 Ger Furl Prol	Tomography ge Tomography /e Tomography ctral Tomography ieralized Tomography ther Reading blems	142 157 165 173 180 186 187
5	Digita	Image Processing	189
	5.1 Disc	crete and Matrix Models	191

v

Α

 5.3 Pseudo-Inverse 5.4 Regularization 5.5 Iterative Inversion Further Reading Problems 	207 214 221 226 226
Spectral Imaging	231

6 **Spectral Imaging** 6.1 Spectral Imaging6.2 Models of Spectral Imaging 233 241 248 6.3 Information Extraction 6.4 Applications of Spectral Subsurface Imaging 257 Further Reading 273 Problems

-	Imaging		
	7.1	Introduction	277
	7.2	Image Registration Algorithms	289
	7.3	Mosaicing	306
	7.4	Change Detection	311
	7.5	Multisensor Imaging	314
		Further Reading	319
		Problems	320

8 **Numerical Simulation**

8.1	Overview of Numerical Methods	324
8.2	Differential Methods	329
8.3	Integral Methods	341
8.4	Modal Methods	346
8.5	Comparison, Limitations, and Validation	349
8.6	Simulation for Sensing and Imaging	356
	Further Reading	357
	Problems	358
De	sign of Subsurface Imaging Systems	361

9 **Design of Subsurface Imaging Systems** 9.1 The Design Process 9.2 Case Study I: Humanitarian Demining

Multi-Dimensional Signals and Systems	388
Further Reading Problems	385 386
9.2 Case Study I: Humanitarian Demining	372

A.1	One-Dimensional Signals and Systems	388
A.2	Two-Dimensional Signals and Systems	394
A.3	Multi-Dimensional Signals and Systems	402
	Further Reading	403

В Linear Algebra 404

Contents Vii

	B.1 Linear Vector SpacesB.2 Linear Transformations: Matrices	405 408
С	Detection and Classification	414
	C.1 Detection	414
	C.2 Classification	420
	Further Reading	423
D	Software Tools	424
	D.1 MATLAB Image Processing Toolbox	424
	D.2 Field Simulation Software	427
	D.3 Hyperspectral Image Analysis Toolbox	429
	D.4 Image Registration Software	430

Index

271

323

362

433