

# Contents

<b>Authors and Contributors</b>	<b>viii</b>
<b>Preface</b>	<b>ix</b>
<b>Acknowledgements</b>	<b>xi</b>
<b>Outline and Roadmap</b>	<b>xiii</b>
<b>1 Overview</b>	<b>1</b>
1.1 Subsurface Imaging: Scope and Applications	2
1.2 Challenges of Subsurface Imaging	5
1.3 Localized and Tomographic Imaging	10
1.4 Mathematics of Subsurface Imaging	13
1.5 Dynamic, Multispectral, Multisensor, and Multiwave Imaging	16
<b>2 Physical Models</b>	<b>21</b>
2.1 Waves: Electromagnetic and Acoustic	22
2.2 Wave Interaction I	37
2.3 Wave Interaction II	58
2.4 Contrast Agents	68
2.5 Sources and Detectors	73
Further Reading	81
Problems	83
<b>3 Localized Imaging</b>	<b>85</b>
3.1 Two-Dimensional Imaging	87
3.2 Three-Dimensional Imaging	108
3.3 Image Restoration	131
Further Reading	135
Problems	136
<b>4 Tomographic Imaging</b>	<b>139</b>
4.1 Ray Tomography	142
4.2 Range Tomography	157
4.3 Wave Tomography	165
4.4 Spectral Tomography	173
4.5 Generalized Tomography	180
Further Reading	186
Problems	187
<b>5 Digital Image Processing</b>	<b>189</b>
5.1 Discrete and Matrix Models	191

5.2	The Inverse Problem	200
5.3	Pseudo-Inverse	207
5.4	Regularization	214
5.5	Iterative Inversion	221
	Further Reading	226
	Problems	226
<b>6</b>	<b>Spectral Imaging</b>	<b>231</b>
6.1	Spectral Imaging	233
6.2	Models of Spectral Imaging	241
6.3	Information Extraction	248
6.4	Applications of Spectral Subsurface Imaging	257
	Further Reading	271
	Problems	273
<b>7</b>	<b>Mosaicing, Change Detection, and Multisensor Imaging</b>	<b>276</b>
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
<b>8</b>	<b>Numerical Simulation</b>	<b>323</b>
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
<b>9</b>	<b>Design of Subsurface Imaging Systems</b>	<b>361</b>
9.1	The Design Process	362
9.2	Case Study I: Humanitarian Demining	372
9.3	Case Study II: Breast Cancer Detection	378
	Further Reading	385
	Problems	386
<b>A</b>	<b>Multi-Dimensional Signals and Systems</b>	<b>388</b>
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
<b>B</b>	<b>Linear Algebra</b>	<b>404</b>

B.1	Linear Vector Spaces	405
B.2	Linear Transformations: Matrices	408
<b>C</b>	<b>Detection and Classification</b>	<b>414</b>
C.1	Detection	414
C.2	Classification	420
	Further Reading	423
<b>D</b>	<b>Software Tools</b>	<b>424</b>
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
	<b>Index</b>	<b>433</b>