

Contents

1. Introductory Remarks on Remote Sensing	
E. SCHANDA	1
1.1 Application Areas of Remote Sensing	1
1.2 Sensing Systems	2
1.3 Remote Sensing and Spectral Constraints	5
2. Aerospace Photography	
A. E. SALERNO	11
2.1 Introduction	11
2.2 Characteristics of Photographic Process	12
2.2.1 Sensitometry General	12
2.2.2 The Characteristic Curve	13
2.2.3 Development Control	20
2.2.4 Exposure Control	21
2.2.5 Film Speed	24
2.2.6 Reciprocity Law Anomalies	27
2.2.7 Density Measurement	28
2.2.8 Measurement of Color	30
2.2.9 Tone Reproduction Theory	32
2.2.10 Spectral Sensitivity	35
2.2.11 Resolution	36
2.2.12 Granularity	39
2.2.13 Dimensional Stability and Mechanical Properties	41
2.3 Cameras and Films	42
2.3.1 Cameras (General)	42
2.3.2 Aerial Cameras — Common Features	42
2.3.3 Optical System	44
2.3.4 Calibration	44
2.3.5 Image Motion	45
2.3.6 Hand Held Cameras	45
2.3.7 Special Cameras	46
2.3.8 Film (General)	49
2.3.9 Aerial Photographic Materials	53
2.3.10 Black-and-White Camera Films	57
2.3.11 Color Camera Films	62

2.4 Photographic Attributes of Earth Sciences	62
2.4.1 Agriculture	63
2.4.2 Geography and Geology	65
2.4.3 Hydrology and Oceanography	68
2.4.4 Anomalies, Atmospheric	69
2.4.5 Factors Affecting the Photo Image	73
2.4.6 Image Formation on Color Film	74
2.4.7 Processing of Color Film	75
2.4.8 Photo Systems, Choice	76
2.4.9 Image Enhancement Procedure	77
Bibliography	77
3. Infrared Sensing Methods	
P. W. SCHAPER	84
3.1 Introduction	84
3.2 The Infrared Radiation Field	85
3.3 Fundamentals of Measurement	87
3.4 Methods of Measurement	92
3.4.1 The Single Element Radiometer	95
3.4.2 Imaging Radiometers	96
3.4.3 Multi Wavelength Channel Radiometers	98
3.4.4 Spectrometers	98
3.4.5 Interferometers	100
3.5 Applications	101
3.6 Data Interpretation Error Sources	105
3.7 Expectations of the Near Future	108
References	109
4. Laser Applications in Remote Sensing	
R. T. H. COLLIS and P. B. RUSSELL	110
4.1 Introduction	110
4.1.1 Scope and Definitions	111
4.1.2 Technical Approaches	111
4.2 Fundamentals of Physical Processes Involved	112
4.2.1 Specular Reflection and Elastic (Non-resonant) Scattering	112
4.2.2 Inelastic and Resonant Scattering	114
4.2.3 Resonant Absorption	118
4.2.4 Doppler Effects	118
4.2.5 Polarization	119
4.3 Instrumentation	11
4.3.1 System Concepts	11
4.3.2 System Configuration	11
4.3.3 Lasers	11
4.3.4 Photodetection	11
4.3.5 Eye Safety	11
4.3.6 Viewpoint of Remote Sensing	11

4.4 Applications	126
4.4.1 General	126
4.4.2 Backscattering Techniques — Non-resonant Elastic Scattering	126
4.4.3 Inelastic and Resonant Backscattering	132
4.4.4 Resonant Absorption	139
4.4.5 Doppler Techniques	142
4.4.6 Polarization	143
References	143

5. Radar Methods

G. P. DE LOOR	147
5.1 General Aspects	147
5.1.1 Introduction	147
5.1.2 Resolution	149
5.1.3 Image Build-up; Flight Procedure	151
5.1.4 Parallax	152
5.1.5 Image Correction	154
5.1.6 Registration of the Radar Signals	155
5.2 Backgrounds	156
5.2.1 Introduction	156
5.2.2 The Radar Equation	156
5.2.3 Ground Returns	157
5.3 Applications	168
5.3.1 Introduction	168
5.3.2 Geography	169
5.3.3 Geology	175
5.3.4 Vegetation Studies	178
5.3.5 Sea, Coastal and Oceanographic Studies	181
5.4 Conclusion	184
References	184

6. Passive Microwave Sensing

E. SCHANDA	187
6.1 Principles of Passive Microwave Remote Sensing	187
6.1.1 Physical Fundamentals of Microwave Radiometry	188
6.1.2 Semitransparent Media	191
6.1.3 The Effects of the Atmosphere	193
6.2 Instrumental Aspects of Microwave Radiometry	198
6.2.1 The Sensitivity of a Microwave Radiometer	198
6.2.2 Other Types of Radiometers	200
6.2.3 Angular Resolution and Range of Passive Microwave Sensing	201
6.2.4 Realisations of Microwave Radiometers	205
6.3 Emissive Properties of Materials on the Surface of the Earth	207
6.3.1 Plane Surfaces of Homogeneous Materials	207
6.3.2 Heterogeneous Media	212
6.3.3 Rough Surfaces	217
6.3.4 Various Investigations on Emissivities	219

6.4 Remote Determination of Atmospheric Constituents by Their Micro-wave Spectra	221
6.4.1 The Absorption Coefficients of the Line Spectra	221
6.4.2 Determinations of Height Profiles	225
6.5 Passive Microwave Remote Sensing of Water, Ice and Snow	227
6.5.1 Investigations of Water Surfaces	228
6.5.2 Investigations of Ice and Snow	232
6.6 Investigations of the Soil, Vegetation and Geological Features	236
6.7 Investigations of the Atmosphere and of Meteorological Features	241
6.7.1 Sounding of Atmospheric Constituents from Molecular Line Radiation	241
6.7.2 Observation of Meteorological Features	245
References	248
7. Applications of Gamma Radiation in Remote Sensing	
R. L. GRASTY	257
7.1 The Natural Gamma-radiation Field	257
7.2 Gamma-ray Detector Systems	261
7.3 Operational Procedures	264
7.3.1 Background Radiation	264
7.3.2 Height Correction	265
7.3.3 Calibration and Spectral Stripping	266
7.4 Applications	267
7.4.1 Mineral Exploration	267
7.4.2 Geological Mapping	269
7.4.3 Water-equivalent Snow Measurements	271
7.4.4 Soil Moisture Measurement	273
7.4.5 Monitoring Nuclear Facilities	273
7.5 Future Prospects	273
References	275
8. Sonar Methods	
D. J. CREASEY	277
8.1 Introduction	277
8.2 Propagation of Acoustic Energy	278
8.2.1 General	278
8.2.2 Absorption Losses in Water	279
8.2.3 Beam Bending in Water	279
8.2.4 Propagation in Air	282
8.3 The Sonar Equation	282
8.3.1 Transducers and Arrays	282
8.3.2 Noise and Reverberation	283
8.3.3 Signal to Noise Ratio and Signal to Reverberation Ratio	284
8.3.4 Interference Signals in Air	285

8.4 Factors Affecting Resolution in a Sonar System	286
8.4.1 General	286
8.4.2 Range Resolution	286
8.4.3 Bearing Resolution	287
8.4.4 Doppler Effect in Sonar	288
8.5 Applications	289
8.5.1 Echo Sounding	289
8.5.2 Sonars with Fixed Beams	290
8.5.3 Mechanically Rotated Sonar Array Systems	291
8.5.4 Side-scan Sonars	291
8.5.5 Sub-bottom Profiling Systems	292
8.5.6 Sonars with Sectors Scanned Electronically	294
8.5.7 Remote Sensing Application of Sonar in Air	301
References	302

9. Digital Picture Processing

PH. HARTL	304
9.1 Introduction	304
9.1.1 General Remarks	304
9.1.2 Relation between Image and Real Scene	305
9.1.3 Enhancement and Filtering	307
9.2 The Elements of an Image Data Processing and Analysis System	307
9.2.1 Data Acquisition Subsystem	308
9.2.2 Data Handling Subsystem	308
9.2.3 Data Preprocessing Subsystem	312
9.2.4 Data Storage and Retrieval Subsystem	313
9.3 Geometric Corrections	314
9.3.1 Linear Transformations	314
9.3.2 Quadratic and Higher Order Transformations	314
9.3.3 Reference Marks	315
9.3.4 Image Gridding	315
9.3.5 Image Registration	315
9.3.6 Geometric Correction Concepts	319
9.4 Image Enhancement and Filtering Processes	320
9.4.1 Enhancement Processes	320
9.4.2 Image Smoothing	321
9.4.3 Image Sharpening	326
9.4.4 Matched Filters	328
9.4.5 Ratio Mapping and Generalization of Image Combination Procedures	329
9.4.6 Pseudocolor Transformation	330
9.5 Feature Extraction and Classification	330
9.5.1 Spectral Features	331
9.5.2 Spatial Features	331
9.5.3 The Decision Process	336

9.5.4 The Decision Criteria	337
9.5.5 Unsupervised Classification	341
9.5.6 Recognizing of Bridges, Rivers, Lakes, and Islands	342
9.6 Appendix 1: The Image Signal in Spatial and Frequency Domain	344
9.6.1 Signals in the Spatial Domain	344
9.6.2 Signals in the Frequency Domain	344
9.7 Appendix 2: Numerical Example for Texture-context Features	346
References	348
Subject Index	351
Color Plates	359