

Contents

1	Introduction	1
	References	6
2	Synthetic Aperture Radar	9
2.1	Radar Remote Sensing with SAR	9
2.2	Geometrical Distortions	13
2.3	Statistical Characterisation of Targets	15
2.4	Radar Cross Section.	20
2.5	Polarimetric Acquisition: The Scattering Matrix	22
2.5.1	The Scattering Matrix	22
2.5.2	The Coordinate System	25
	References	26
3	Radar Polarimetry	29
3.1	Introduction	29
3.2	Wave Polarimetry	29
3.2.1	Polarisation Ellipse	29
3.2.2	Jones Vectors	31
3.2.3	Stokes Vectors	32
3.2.4	Poincaré Polarisation Sphere	34
3.2.5	Wave Decomposition Theorems	35
3.3	Target Polarimetry: Single Targets	37
3.3.1	Sinclair Matrix and Basis Transformation	38
3.3.2	Scattering Features Vectors	39
3.3.3	Backscattering Case	40
3.3.4	Polarisation Fork.	42
3.3.5	Huynen Single Target Decomposition	44
3.4	Target Polarimetry: Partial Targets	45
3.4.1	Muller and Graves Matrices	46

3.4.2	Covariance Matrix.	47
3.4.3	Eigenvalue Decomposition (Cloude–Pottier).	49
3.4.4	α Scattering Model	51
3.5	Polarimetric Detection	52
3.5.1	Detectors Based on Statistical Approaches	53
3.5.2	Detector Based on Physical Approaches	53
3.5.3	Polarimetric Whitening Filter	55
3.5.4	Comparison of Detectors	58
	References	58
4	Polarimetric Detector.	63
4.1	Introduction	63
4.2	Derivation Using an Algebraic Approach	63
4.2.1	Weighting of Vector Components	63
4.2.2	Detector.	65
4.3	Mathematical Derivation with a Physical Approach.	66
4.3.1	Perturbation Analysis and Coherence Detector	66
4.3.2	Bias Removal: Final Detector.	73
4.3.3	Generalised Detector	76
4.4	Detector Interpretation	77
4.4.1	Geometrical Interpretation	77
4.4.2	Physical Interpretation	79
4.5	Parameters Selection	80
4.5.1	Reduction Ratios (<i>RedR</i>) and Threshold.	80
4.5.2	Perturbed Target Selection: <i>RedR</i>	84
4.6	Algorithm Implementation	86
4.6.1	Gram–Schmidt Ortho-normalisation	86
4.6.2	Flow Chart.	87
4.7	Target to Detect	88
4.7.1	Standard Single Targets.	89
	References	91
5	Polarimetric Detector Statistics.	93
5.1	Introduction	93
5.2	Analytic Detector Probability Density Function.	93
5.2.1	Coloured Clutter Hypothesis.	94
5.2.2	White Clutter Hypothesis.	98
5.2.3	General Hypothesis on Clutter	103
5.2.4	General Hypothesis on Target and Clutter	107
5.3	Probabilities	108
5.3.1	Coloured Clutter Hypothesis.	109
5.3.2	White Clutter Hypothesis.	113
5.4	Receiver Operating Characteristic	117

- 5.4.1 Coloured Clutter Hypothesis. 117
 - 5.4.2 White Clutter Hypothesis. 117
 - 5.4.3 Selection of the Threshold 123
 - 5.5 Estimation of DF Through Numerical Simulation 123
 - 5.5.1 Coloured Clutter Hypothesis. 124
 - 5.5.2 White Clutter Hypothesis. 129
 - References 131
- 6 Validation with Airborne Data 133
 - 6.1 Introduction 133
 - 6.2 Presentation of the E-SAR Data and General Considerations . . . 134
 - 6.3 Standard Target Detection 138
 - 6.4 Selectable Detection 148
 - 6.5 Polarimetric Characterisation 157
 - 6.6 Comparison with Another Polarimetric Detector: PWF 157
 - References 159
- 7 Validation with Satellite Data 161
 - 7.1 Introduction 161
 - 7.2 ALOS PALSAR 164
 - 7.2.1 Description of the Data and General Considerations . . . 164
 - 7.2.2 Standard Targets Detection 168
 - 7.3 RADRSAT-2 176
 - 7.3.1 Description of the Data 176
 - 7.3.2 Standard Targets Detection 180
 - 7.4 TerraSAR-X 185
 - 7.4.1 Description of the Data 185
 - 7.4.2 Standard Target Detection 188
 - References 190
- 8 Recent Applications of Perturbation Filters 193
 - 8.1 Introduction 193
 - 8.2 Partial Target Detector 193
 - 8.2.1 Formulation 193
 - 8.2.2 Physical Feasibility 196
 - 8.2.3 Parameter Selection. 197
 - 8.2.4 Dual Polarimetric Detection 198
 - 8.3 Classifier 199
 - 8.3.1 Formulation 199
 - 8.3.2 Parameter Selection. 200
 - 8.3.3 Supervised and Unsupervised Versions 200

8.4	Validation of Partial Target Detector	201
8.4.1	Datasets Employed	201
8.4.2	Comparison Between Single and Partial Target Detector.	201
8.4.3	Satellite Data: Historical Fire Scar (hfs) Detection	202
8.4.4	Satellite Data: Classification.	207
8.4.5	Satellite Data: Dual Polarimetric Detection	211
8.5	Final Remarks.	214
	References	214
9	Conclusions	217
	References	220
	Appendix 1: Geometrical Perturbation with the Huynen Parameters	223
	Appendix 2: Neglecting the Cross Terms	231