

2.1.3	Scale	40
2.1.4	Polarity, shadows, and image form	40
2.1.5	Methodology for algorithm evaluation	42
2.1.5.1	Evaluation criteria for production systems	42
2.1.5.2	Target detection: machine versus human	43
2.2	Simple Detection Algorithms	43
2.2.1	Triple-window filter	43
2.2.2	Hypothesis testing as applied to an image	44
2.2.3	Comparison of two empirically determined means: variations on the T-test	45
2.2.4	Tests involving variance, variation, and dispersion	48
2.2.5	Tests for significance of hot spot	50
2.2.6	Nonparametric tests	51
2.2.6.1	Percent-bright tests	52
2.2.7	Tests involving textures and fractals	53
2.2.8	Tests involving blob edge strength	53
2.2.9	Hybrid tests	54
2.2.10	Triple-window filters using several inner-window geometries	55
2.3	More-Complex Detectors	55
2.3.1	Neural network detectors	55
2.3.2	Discriminant functions	56
2.3.3	Deformable templates	57
2.4	Grand Paradigms	57
2.4.1	Geometrical and cultural intelligence	58
2.4.2	Neuromorphic paradigm	59
2.4.3	Learning-on-the-fly	59
2.4.4	Integrated sensing and processing	60
2.4.5	Bayesian surprise	61
2.4.6	Modeling and simulation	62
2.4.7	SIFT and SURF	63
2.4.8	Detector designed to operational scenario	63
2.5	Traditional SAR and Hyperspectral Target Detectors	64
2.5.1	Target detection in SAR imagery	65
2.5.2	Target detection in hyperspectral imagery	66
2.6	Conclusions and Future Direction	68
	References	69
	Appendices	71
3	Target Classifier Strategies	79
3.1	Introduction	79
3.1.1	Parables and paradoxes	79
3.2	Main Issues to Consider in Target Classification	82
3.2.1	Issue 1: Concept of operations	83

3.2.2	Issue 2: Inputs and outputs	83
3.2.3	Issue 3: Target classes	84
3.2.4	Issue 4: Target variations	85
3.2.5	Issue 5: Platform issues	87
3.2.6	Issue 6: Under what conditions does a sensor supply useful data?	87
3.2.7	Issue 7: Sensor issues	88
3.2.8	Issue 8: Processor	89
3.2.9	Issue 9: Conveying classification results to the human-in-the-loop	89
3.2.10	Issue 10: Feasibility	91
3.3	Feature Extraction	94
3.4	Feature Selection	99
3.5	Examples of Feature Types	102
3.5.1	Histogram of oriented gradients	103
3.5.2	Histogram of optical flow feature vector	105
3.6	Examples of Classifiers	105
3.6.1	Simple classifiers	106
3.6.1.1	One-class classifiers	106
3.6.1.2	Two-class linear classifiers	106
3.6.1.3	Support vector machine	107
3.6.2	Basic classifiers	110
3.6.2.1	Single-nearest-neighbor classifier	110
3.6.2.2	Naive Bayes classifier	112
3.6.2.3	Perceptron	113
3.6.2.4	Learning vector quantization family of algorithms	115
3.6.2.5	Feedforward multilayer perceptron trained with backpropagation of error	116
3.6.2.6	Mean-field theory networks	116
3.6.2.7	Model-based classifiers	118
3.6.2.8	Map-seeking circuits	118
3.6.2.9	Ensemble classifiers	120
3.6.3	Contest-winning and newly popular classifiers	120
3.6.3.1	Hierarchical temporal memory	122
3.6.3.2	Long short-term memory recurrent neural network	122
3.6.3.3	Convolutional neural network	123
3.6.3.4	Sentient ATR	126
3.7	Discussion	127
	References	133
4	Unification of Automatic Target Tracking and Automatic Target Recognition	137
4.1	Introduction	137
4.2	Categories of Tracking Problems	140

4.2.1	Number of targets	140
4.2.2	Size of targets	141
4.2.3	Sensor type	142
4.2.4	Target type	143
4.3	Tracking Problems	143
4.3.1	Point target tracking	143
4.3.2	Video tracking	148
4.3.2.1	Correlation tracking (video data)	149
4.3.2.2	Feature-vector-aided tracking (video data)	150
4.3.2.3	Mean-shift-based moving object tracker (video tracking)	151
4.4	Extensions of Target Tracking	152
4.4.1	Activity recognition (AR)	152
4.4.2	Patterns-of-life and forensics	154
4.5	Collaborative ATT and ATR (ATT↔ATR)	155
4.5.1	ATT data useful to ATR	155
4.5.2	ATR data useful to ATT	156
4.6	Unification of ATT and ATR (ATT∪ATR)	157
4.6.1	Visual pursuit	158
4.6.2	A bat's echolocation of flying insects	159
4.6.3	Fused ATT∪ATR	160
4.6.3.1	Spatiotemporal target detection	161
4.6.3.2	Forecast of features and classes	163
4.6.3.3	Detection-to-track association	165
4.6.3.4	Track maintenance	166
4.6.3.5	Incorporation of higher-level knowledge	166
4.6.3.6	Implementation	167
4.7	Discussion	167
	References	168
5	How Smart Is Your Automatic Target Recognizer?	171
5.1	Introduction	171
5.2	Test for Determining the Intelligence of an ATR	173
5.2.1	Does the ATR understand human culture?	174
5.2.2	Can the ATR deduce the gist of a scene?	174
5.2.3	Does the ATR understand physics?	175
5.2.4	Can the ATR participate in a pre-mission briefing?	177
5.2.5	Does the ATR possess deep conceptual understanding?	177
5.2.6	Can the ATR adapt to the situation, learn on-the-fly, and make analogies?	178
5.2.7	Does the ATR understand the rules of engagement?	179
5.2.8	Does the ATR understand order of battle and force structure?	181
5.2.9	Can the ATR control platform motion?	182

5.2.10 Can the ATR fuse information from a wide variety of sources?	183
5.2.11 Does the ATR possess metacognition?	184
5.3 Sentient versus Sapient ATR	185
5.4 Discussion: Where Is ATR Headed?	186
References	190
Appendix 1: Resources	191
Appendix 2: Acronyms	225
<i>Index</i>	231