

Contents

1. Color Spaces	1
1.1 Basics of Color Vision	1
1.2 The CIE Chromaticity-based Models	4
1.3 The CIE-RGB Color Model	9
1.4 Gamma Correction	13
1.5 Linear and Non-linear RGB Color Spaces	16
1.5.1 Linear RGB Color Space	16
1.5.2 Non-linear RGB Color Space	17
1.6 Color Spaces Linearly Related to the RGB	20
1.7 The YIQ Color Space	23
1.8 The HSI Family of Color Models	25
1.9 Perceptually Uniform Color Spaces	32
1.9.1 The CIE $L^*u^*v^*$ Color Space	33
1.9.2 The CIE $L^*a^*b^*$ Color Space	35
1.9.3 Cylindrical $L^*u^*v^*$ and $L^*a^*b^*$ Color Space	37
1.9.4 Applications of $L^*u^*v^*$ and $L^*a^*b^*$ spaces	37
1.10 The Munsell Color Space	39
1.11 The Opponent Color Space	41
1.12 New Trends	42
1.13 Color Images	45
1.14 Summary	45
2. Color Image Filtering	51
2.1 Introduction	51
2.2 Color Noise	52
2.3 Modeling Sensor Noise	53
2.4 Modeling Transmission Noise	55
2.5 Multivariate Data Ordering Schemes	58
2.5.1 Marginal Ordering	59
2.5.2 Conditional Ordering	62
2.5.3 Partial Ordering	62
2.5.4 Reduced Ordering	63
2.6 A Practical Example	67
2.7 Vector Ordering	69

2.8	The Distance Measures	70
2.9	The Similarity Measures	72
2.10	Filters Based on Marginal Ordering	77
2.11	Filters Based on Reduced Ordering	81
2.12	Filters Based on Vector Ordering	89
2.13	Directional-based Filters	92
2.14	Computational Complexity	98
2.15	Conclusion	100
3.	Adaptive Image Filters	107
3.1	Introduction	107
3.2	The Adaptive Fuzzy System	109
3.2.1	Determining the Parameters	112
3.2.2	The Membership Function	113
3.2.3	The Generalized Membership Function	115
3.2.4	Members of the Adaptive Fuzzy Filter Family	116
3.2.5	A Combined Fuzzy Directional and Fuzzy Median Filter	122
3.2.6	Comments	125
3.2.7	Application to $1-D$ Signals	128
3.3	The Bayesian Parametric Approach	131
3.4	The Non-parametric Approach	137
3.5	Adaptive Morphological Filters	146
3.5.1	Introduction	146
3.5.2	Computation of the NOP and the NCP	152
3.5.3	Computational Complexity and Fast Algorithms	154
3.6	Simulation Studies	157
3.7	Conclusions	173
4.	Color Edge Detection	179
4.1	Introduction	179
4.2	Overview Of Color Edge Detection Methodology	181
4.2.1	Techniques Extended From Monochrome Edge Detection	181
4.2.2	Vector Space Approaches	183
4.3	Vector Order Statistic Edge Operators	189
4.4	Difference Vector Operators	194
4.5	Evaluation Procedures and Results	197
4.5.1	Probabilistic Evaluation	198
4.5.2	Noise Performance	200
4.5.3	Subjective Evaluation	201
4.6	Conclusion	203

5. Color Image Enhancement and Restoration	209
5.1 Introduction	209
5.2 Histogram Equalization	210
5.3 Color Image Restoration	214
5.4 Restoration Algorithms	217
5.5 Algorithm Formulation	220
5.5.1 Definitions	220
5.5.2 Direct Algorithms	223
5.5.3 Robust Algorithms	227
5.6 Conclusions	229
6. Color Image Segmentation	237
6.1 Introduction	237
6.2 Pixel-based Techniques	239
6.2.1 Histogram Thresholding	239
6.2.2 Clustering	242
6.3 Region-based Techniques	247
6.3.1 Region Growing	248
6.3.2 Split and Merge	250
6.4 Edge-based Techniques	252
6.5 Model-based Techniques	253
6.5.1 The Maximum A-posteriori Method	254
6.5.2 The Adaptive MAP Method	255
6.6 Physics-based Techniques	256
6.7 Hybrid Techniques	257
6.8 Application	260
6.8.1 Pixel Classification	260
6.8.2 Seed Determination	262
6.8.3 Region Growing	267
6.8.4 Region Merging	269
6.8.5 Results	271
6.9 Conclusion	273
7. Color Image Compression	279
7.1 Introduction	279
7.2 Image Compression Comparison Terminology	282
7.3 Image Representation for Compression Applications	285
7.4 Lossless Waveform-based Image Compression Techniques	286
7.4.1 Entropy Coding	286
7.4.2 Lossless Compression Using Spatial Redundancy	288
7.5 Lossy Waveform-based Image Compression Techniques	290
7.5.1 Spatial Domain Methodologies	290
7.5.2 Transform Domain Methodologies	292
7.6 Second Generation Image Compression Techniques	304
7.7 Perceptually Motivated Compression Techniques	307

7.7.1	Modeling the Human Visual System	307
7.7.2	Perceptually Motivated DCT Image Coding	311
7.7.3	Perceptually Motivated Wavelet-based Coding	313
7.7.4	Perceptually Motivated Region-based Coding	317
7.8	Color Video Compression	319
7.9	Conclusion	324
8.	Emerging Applications	329
8.1	Input Analysis Using Color Information	331
8.2	Shape and Color Analysis	337
8.2.1	Fuzzy Membership Functions	338
8.2.2	Aggregation Operators	340
8.3	Experimental Results	343
8.4	Conclusions	345
A.	Companion Image Processing Software	349
A.1	Image Filtering	350
A.2	Image Analysis	350
A.3	Image Transforms	351
A.4	Noise Generation	351
Index		353