

Contents

1	Introduction and Theory	1
1.1	General Aspects	1
1.2	The State of Traditional Image Processing	2
1.2.1	Generalisation <i>versus</i> Discrimination	2
1.2.2	“The World of Inner Products”	3
1.2.3	The Mammalian Visual System	4
1.2.4	Where Do We Go From Here?	4
1.3	Visual Cortex Theory	5
1.3.1	A Brief Overview of the Visual Cortex	5
1.3.2	The Hodgkin–Huxley Model	6
1.3.3	The Fitzhugh–Nagumo Model	7
1.3.4	The Eckhorn Model	8
1.3.5	The Rybak Model	9
1.3.6	The Parodi Model	10
1.4	Summary	10
2	Theory of Digital Simulation	11
2.1	The Pulse-Coupled Neural Network	11
2.1.1	The Original PCNN Model	11
2.1.2	Time Signatures	16
2.1.3	The Neural Connections	18
2.1.4	Fast Linking	21
2.1.5	Fast Smoothing	22
2.1.6	Analogue Time Simulation	23
2.2	The ICM – A Generalized Digital Model	24
2.2.1	Minimum Requirements	25
2.2.2	The ICM	26
2.2.3	Interference	27
2.2.4	Curvature Flow Models	31
2.2.5	Centripetal Autowaves	32
2.3	Summary	34

3	Automated Image Object Recognition	35
3.1	Important Image Features	35
3.2	Image Segmentation – A Red Blood Cell Example	41
3.3	Image Segmentation – A Mammography Example	42
3.4	Image Recognition – An Aircraft Example	43
3.5	Image Classification – Aurora Borealis Example	44
3.6	The Fractional Power Filter	46
3.7	Target Recognition – Binary Correlations	47
3.8	Image Factorisation	51
3.9	A Feedback Pulse Image Generator	52
3.10	Object Isolation	55
3.11	Dynamic Object Isolation	58
3.12	Shadowed Objects	60
3.13	Consideration of Noisy Images	62
3.14	Summary	67
4	Image Fusion	69
4.1	The Multi-spectral Model	69
4.2	Pulse-Coupled Image Fusion Design	71
4.3	A Colour Image Example	73
4.4	Example of Fusing Wavelet Filtered Images	75
4.5	Detection of Multi-spectral Targets	75
4.6	Example of Fusing Wavelet Filtered Images	80
4.7	Summary	81
5	Image Texture Processing	83
5.1	Pulse Spectra	83
5.2	Statistical Separation of the Spectra	87
5.3	Recognition Using Statistical Methods	88
5.4	Recognition of the Pulse Spectra via an Associative Memory	89
5.5	Summary	92
6	Image Signatures	93
6.1	Image Signature Theory	93
6.1.1	The PCNN and Image Signatures	94
6.1.2	Colour Versus Shape	95
6.2	The Signatures of Objects	95
6.3	The Signatures of Real Images	97
6.4	Image Signature Database	99
6.5	Computing the Optimal Viewing Angle	100
6.6	Motion Estimation	103
6.7	Summary	106

7	Miscellaneous Applications	107
7.1	Foveation.....	107
7.1.1	The Foveation Algorithm	108
7.1.2	Target Recognition by a PCNN Based Foveation Model	110
7.2	Histogram Driven Alterations	113
7.3	Maze Solutions	115
7.4	Barcode Applications	116
7.4.1	Barcode Generation from Data Sequence and Images	117
7.4.2	PCNN Counter	121
7.4.3	Chemical Indexing	121
7.4.4	Identification and Classification of Galaxies	126
7.4.5	Navigational Systems	131
7.4.6	Hand Gesture Recognition	134
7.4.7	Road Surface Inspection	137
7.5	Summary	141
8	Hardware Implementations	143
8.1	Theory of Hardware Implementation	143
8.2	Implementation on a CNAPs Processor	144
8.3	Implementation in VLSI	146
8.4	Implementation in FPGA	146
8.5	An Optical Implementation	151
8.6	Summary	153
	References	155
	Index	163