Contents

1 **Biological Models** 1
  1.1 Introduction 3
  1.2 Biological Foundation 5
  1.3 Hodgkin-Huxley 6
  1.4 Fitzhugh-Nagumo 7
  1.5 Eckhorn Model 9
  1.6 Rybak Model 10
  1.7 Parodi Model 10
  1.8 Summary 11

2 **Programming in Python** 13
  2.1 Environment 13
    2.1.1 Command Interface. 14
    2.1.2 IDLE 14
    2.1.3 Establishing a Working Environment 14
  2.2 Data Types and Simple Math. 15
  2.3 Tuples, Lists, and Dictionaries 16
    2.3.1 Tuples. 16
    2.3.2 Lists 17
    2.3.3 Dictionaries 18
  2.4 Slicing 19
  2.5 Strings. 20
    2.5.1 String Functions 21
    2.5.2 Type Casting 23
  2.6 Control 23
  2.7 Input and Output 25
    2.7.1 Basic Files. 25
    2.7.2 Pickle 26
  2.8 Functions. 27
  2.9 Modules 28
  2.10 Object Oriented Programming 30
    2.10.1 Content of a Class 30
    2.10.2 Operator Definitions 30

2.10.3 Inheritance . . . 31
2.11 Error Checking . . . 32
2.12 Summary . . . 33

3 NumPy, SciPy and Python Image Library . . . 35
3.1 NumPy . . . 35
3.1.1 Creating Arrays . . . 35
3.1.2 Converting Arrays . . . 38
3.1.3 Matrix: Vector Multiplications . . . 38
3.1.4 Justification for Arrays . . . 39
3.1.5 Data Types . . . 41
3.1.6 Sorting . . . 43
3.1.7 Conversions to Strings and Lists . . . 45
3.1.8 Changing the Matrix . . . 47
3.1.9 Advanced Slicing . . . 47
3.2 SciPy . . . 49
3.3 Designing in Numpy . . . 52
3.4 Python Image Library . . . 54
3.4.1 Reading an Image . . . 54
3.4.2 Writing an Image . . . 55
3.4.3 Transforming an Image . . . 56
3.5 Summary . . . 56

4 The PCNN and ICM . . . 57
4.1 The PCNN . . . 57
4.1.1 Original Model . . . 57
4.1.2 Implementing in Python . . . 59
4.1.3 Spiking Behaviour . . . 61
4.1.4 Collective Behaviour . . . 64
4.1.5 Time Signatures . . . 66
4.1.6 Neural Connections . . . 67
4.1.7 Fast Linking . . . 70
4.1.8 Models in Analogue Time . . . 73
4.2 The ICM . . . 74
4.2.1 Minimum Requirements . . . 75
4.2.2 ICM Theory . . . 76
4.2.3 Connections in the ICM . . . 77
4.2.4 Python Implementation . . . 83
4.3 Summary . . . 84

5 Image Analysis . . . 87
5.1 Pertinent Image Information . . . 87
5.2 Image Segmentation . . . 92

5.2.1 Blood Cells . . . 92
5.2.2 Mammography . . . 92
5.3 Adaptive Segmentation . . . 95
5.4 Focus and Foveation . . . 96
5.4.1 The Foveation Algorithm. . . . 97
5.4.2 Target Recognition by a PCNN-Based Foveation Model . . . 99
5.5 Image Factorisation. . . . 104
5.6 Summary . . . 105

6 Feedback and Isolation . . . 107
6.1 A Feedback PCNN . . . 107
6.2 Object Isolation . . . 109
6.2.1 Input Normalisation . . . 111
6.2.2 Creating the Filter . . . 111
6.2.3 Edge Enhancement of Pulse Images . . . 113
6.2.4 Correlation and Modifications . . . 114
6.2.5 Peak Detection . . . 116
6.2.6 Modifications to the Input and PCNN . . . 116
6.2.7 Drivers . . . 118
6.3 Dynamic Object Isolation . . . 119
6.4 Shadowed Objects . . . 119
6.5 Consideration of Noisy Images. . . . 122
6.6 Summary . . . 125

7 Recognition and Classification . . . 127
7.1 Aircraft . . . 127
7.2 Aurora Borealis . . . 128
7.3 Target Identification: Binary Correlations . . . 129
7.4 Galaxies . . . 133
7.5 Hand Gestures . . . 137
7.6 Road Surface Inspection . . . 139
7.7 Numerals . . . 143
7.7.1 Data Set . . . 143
7.7.2 Isolating a Class for Training . . . 144
7.8 Generating Pulse Images . . . 145
7.8.1 Analysis of the Signatures . . . 146
7.9 Face Location and Identification. . . . 148
7.10 Summary . . . 153

8 Texture Recognition . . . 155
8.1 Pulse Spectra . . . 155
8.2 Statistical Separation of the Spectra . . . 159

8.3 Recognition Using Statistical Methods 160
8.4 Recognition of the Pulse Spectra via an Associative Memory 161
8.5 Biological Application 162
8.6 Texture Study 167
8.7 Summary 170

9 Colour and Multiple Channels 171
9.1 The Model 171
9.1.1 Colour Example 172
9.1.2 Python Implementation 176
9.2 Multi-Spectral Example 180
9.3 Application of Colour Models 183
9.4 Summary 185

10 Image Signatures 187
10.1 Image Signature Theory 187
10.1.1 The PCNN and Image Signatures 188
10.1.2 Colour Versus Shape 189
10.2 The Signature of Objects 189
10.3 The Signatures of Real Images 191
10.4 Image Signature Database 192
10.5 Computing the Optimal Viewing Angle 193
10.6 Motion Estimation 196
10.7 Summary 198

11 Logic 201
11.1 Maze Running and TSP 201
11.2 Barcodes and Navigation 203
11.3 Summary 208

Appendix A: Image Converters 209

Appendix B: The Geometry Module 215

Appendix C: The Fractional Power Filter 217

Appendix D: Correlation 219

Appendix E: The FAAM 223

Appendix F: Principal Component Analysis 227

References 229

Index 235

http://www.springer.com/978-3-642-36876-9

Image Processing using Pulse-Coupled Neural Networks
Applications in Python
Lindblad, Th.; Kinser, J.
2013, XXIV, 238 p., Hardcover
ISBN: 978-3-642-36876-9