

# Contents

<b>1</b>	<b>New Approaches for Hierarchical Image Decomposition, Based on IDP, SVD, PCA and KPCA</b> . . . . .	<b>1</b>
	Roumen Kountchev and Roumiana Kountcheva	
1.1	Introduction . . . . .	2
1.2	Related Work . . . . .	3
1.3	Image Representation Based on Branched Inverse Difference Pyramid . . . . .	4
1.3.1	Principles for Building the Inverse Difference Pyramid . . . . .	4
1.3.2	Mathematical Representation of n-Level IDP . . . . .	5
1.3.3	Reduced Inverse Difference Pyramid . . . . .	8
1.3.4	Main Principle for Branched IDP Building . . . . .	8
1.3.5	Mathematical Representation for One BIDP Branch . . . . .	9
1.3.6	Transformation of the Retained Coefficients into Sub-blocks of Size $2 \times 2$ . . . . .	11
1.3.7	Experimental Results . . . . .	13
1.4	Hierarchical Singular Value Image Decomposition . . . . .	15
1.4.1	SVD Algorithm for Matrix Decomposition . . . . .	17
1.4.2	Particular Case of the SVD for Image Block of Size $2 \times 2$ . . . . .	18
1.4.3	Hierarchical SVD for a Matrix of Size $2^n \times 2^n$ . . . . .	19
1.4.4	Computational Complexity of the Hierarchical SVD of Size $2^n \times 2^n$ . . . . .	23
1.4.5	Representation of the HSVD Algorithm Through Tree-like Structure . . . . .	25
1.5	Hierarchical Adaptive Principal Component Analysis for Image Sequences . . . . .	27
1.5.1	Principle for Decorrelation of Image Sequences by Hierarchical Adaptive PCA . . . . .	30

- 1.5.2 Description of the Hierarchical Adaptive PCA Algorithm . . . . . 30
- 1.5.3 Setting the Number of the Levels and the Structure of the HAPCA Algorithm . . . . . 35
- 1.5.4 Experimental Results . . . . . 39
- 1.6 Hierarchical Adaptive Kernel Principal Component Analysis for Color Image Segmentation . . . . . 42
  - 1.6.1 Mathematical Representation of the Color Adaptive Kernel PCA. . . . . 42
  - 1.6.2 Algorithm for Color Image Segmentation by Using HAKPCA . . . . . 47
  - 1.6.3 Experimental Results . . . . . 50
- 1.7 Conclusions . . . . . 53
- 2 Intelligent Digital Signal Processing and Feature Extraction Methods . . . . . 59**

János Szalai and Ferenc Emil Mózes

  - 2.1 Introduction. . . . . 59
  - 2.2 The Fourier Transform . . . . . 60
    - 2.2.1 Application of the Fourier Transform . . . . . 62
  - 2.3 The Short-Time Fourier Transform. . . . . 64
    - 2.3.1 Application of the Short-Time Fourier Transform . . . . . 65
  - 2.4 The Wavelet Transform . . . . . 67
    - 2.4.1 Application of the Wavelet Transform. . . . . 70
  - 2.5 The Hilbert-Huang Transform . . . . . 71
    - 2.5.1 Introducing the Instantaneous Frequency . . . . . 71
    - 2.5.2 Computing the Instantaneous Frequency . . . . . 72
    - 2.5.3 Application of the Hilbert-Huang Transform . . . . . 76
  - 2.6 Hybrid Signal Processing Systems . . . . . 80
    - 2.6.1 The Discrete Wavelet Transform and Fuzzy C-Means Clustering . . . . . 80
    - 2.6.2 Automatic Sleep Stage Classification . . . . . 82
    - 2.6.3 The Hilbert-Huang Transform and Support Vector Machines . . . . . 85
  - 2.7 Conclusions . . . . . 88
  - References . . . . . 88
- 3 Multi-dimensional Data Clustering and Visualization via Echo State Networks . . . . . 93**

Petia Koprinkova-Hristova

  - 3.1 Introduction. . . . . 93
  - 3.2 Echo State Networks and Clustering Procedure . . . . . 95
    - 3.2.1 Echo State Networks Basics . . . . . 95
    - 3.2.2 Effects of IP Tuning Procedure . . . . . 97
    - 3.2.3 Clustering Algorithms. . . . . 101

3.3	Examples . . . . .	105
3.3.1	Clustering of Steel Alloys in Dependence on Their Composition . . . . .	105
3.3.2	Clustering and Visualization of Multi-spectral Satellite Images . . . . .	106
3.3.3	Clustering of Working Regimes of an Industrial Plant. . . . .	109
3.3.4	Clustering of Time Series from Random Dots Motion Patterns . . . . .	111
3.3.5	Clustering and 2D Visualization of “Sound Pictures” . . . . .	114
3.4	Summary of Results and Discussion. . . . .	117
3.5	Conclusions . . . . .	119
	References . . . . .	120
<b>4</b>	<b>Unsupervised Clustering of Natural Images in Automatic Image Annotation Systems . . . . .</b>	<b>123</b>
	Margarita Favorskaya, Lakhmi C. Jain and Alexander Proskurin	
4.1	Introduction. . . . .	124
4.2	Related Work . . . . .	125
4.2.1	Unsupervised Segmentation of Natural Images. . . . .	125
4.2.2	Unsupervised Clustering of Images. . . . .	128
4.3	Preliminary Unsupervised Image Segmentation . . . . .	129
4.4	Feature Extraction Using Parallel Computations . . . . .	131
4.4.1	Color Features Representation . . . . .	133
4.4.2	Calculation of Texture Features . . . . .	134
4.4.3	Fractal Features Extraction . . . . .	135
4.4.4	Enhanced Region Descriptor . . . . .	137
4.4.5	Parallel Computations of Features. . . . .	138
4.5	Clustering of Visual Words by Enhanced SOINN . . . . .	139
4.5.1	Basic Concepts of ESOINN. . . . .	140
4.5.2	Algorithm of ESOINN Functioning . . . . .	141
4.6	Experimental Results . . . . .	143
4.7	Conclusion and Future Development . . . . .	151
	References . . . . .	152
<b>5</b>	<b>An Evolutionary Optimization Control System for Remote Sensing Image Processing. . . . .</b>	<b>157</b>
	Victoria Fox and Mariofanna Milanova	
5.1	Introduction. . . . .	157
5.2	Background Techniques . . . . .	159
5.2.1	Darwinian Particle Swarm Optimization . . . . .	159
5.2.2	Total Variation for Texture-Structure Separation. . . . .	162
5.2.3	Multi-phase Chan-Vese Active Contour Without Edges . . . . .	166

5.3	Evolutionary Optimization of Segmentation. . . . .	167
5.3.1	Darwinian PSO for Thresholding . . . . .	167
5.3.2	Novel Darwinian PSO for Relative Total Variation. . . . .	169
5.3.3	Multi-phase Active Contour Without Edges with Optimized Initial Level Mask . . . . .	170
5.3.4	Workflow of Proposed System. . . . .	173
5.4	Experimental Results . . . . .	174
5.4.1	Results . . . . .	174
5.4.2	Discussion. . . . .	179
5.4.3	Conclusion and Future Research. . . . .	179
	References . . . . .	180
<b>6</b>	<b>Tissue Segmentation Methods Using 2D Histogram</b>	
	<b>Matching in a Sequence of MR Brain Images . . . . .</b>	<b>183</b>
	Vladimir Kanchev and Roumen Kountchev	
6.1	Introduction. . . . .	184
6.2	Related Works. . . . .	185
6.3	Overview of the Developed Segmentation Algorithm . . . . .	188
6.4	Preprocessing and Construction of a Model and Test 2D Histograms . . . . .	189
6.4.1	Transductive Learning. . . . .	190
6.4.2	MRI Data Preprocessing . . . . .	190
6.4.3	Construction of a 2D Histogram. . . . .	191
6.4.4	Separation into MR Image Subsequences . . . . .	192
6.4.5	Types of 2D Histograms and Preprocessing. . . . .	194
6.5	Matching and Classification of a 2D Histogram . . . . .	196
6.5.1	Construct Train 2D Histogram Segments Using 2D Histogram Matching. . . . .	197
6.5.2	2D Histogram Classification After Distance Metric Learning . . . . .	199
6.6	Segmentation Through Back Projection. . . . .	204
6.7	Experimental Results . . . . .	207
6.7.1	Test Data Sets and Parameters of the Developed Algorithm . . . . .	207
6.7.2	Segmentation Results . . . . .	209
6.8	Discussion . . . . .	217
6.9	Conclusion . . . . .	219
	References . . . . .	219
<b>7</b>	<b>Multistage Approach for Simple Kidney Cysts</b>	
	<b>Segmentation in CT Images . . . . .</b>	<b>223</b>
	Veska Georgieva and Ivo Draganov	
7.1	Introduction. . . . .	224
7.1.1	Medical Aspect of the Problem for Kidney Cyst Detection . . . . .	224

7.1.2	Review of Segmentation Methods . . . . .	225
7.1.3	Proposed Approach . . . . .	229
7.2	Preprocessing Stage of CT Images . . . . .	230
7.2.1	Noise Reduction with Median Filter . . . . .	230
7.2.2	Noise Reduction Based on Wavelet Packet Decomposition and Adaptive Threshold . . . . .	231
7.2.3	Contrast Limited Adaptive Histogram Equalization (CLAHE) . . . . .	232
7.3	Segmentation Stage . . . . .	232
7.3.1	Segmentation Based on Split and Merge Algorithm . . . . .	232
7.3.2	Clustering Classification of Segmented CT Image. . . . .	234
7.3.3	Segmentation Based on Texture Analysis . . . . .	234
7.4	Experimental Results . . . . .	239
7.5	Discussion . . . . .	247
7.6	Conclusion . . . . .	248
	References . . . . .	249
<b>8</b>	<b>Audio Visual Attention Models in the Mobile Robots Navigation . . . . .</b>	<b>253</b>
	Snejana Pleshkova and Alexander Bekiarski	
8.1	Introduction. . . . .	254
8.2	Related Work . . . . .	254
8.3	The Basic Definitions of the Human Audio Visual Attention. . . . .	256
8.4	General Probabilistic Model of the Mobile Robot Audio Visual Attention. . . . .	257
8.5	Audio Visual Attention Model Applied in the Audio Visual Mobile Robot System. . . . .	263
8.5.1	Room Environment Model for Description of Indoor Initial Audio Visual Attention . . . . .	263
8.5.2	Development of the Algorithm for Definition of the Mobile Robot Initial Audio Visual Attention Model. . . . .	266
8.5.3	Definition of the Initial Mobile Robot Video Attention Model with Additional Information from the Laser Range Finder Scan . . . . .	272
8.5.4	Development of the Initial Mobile Robot Video Attention Model Localization with Additional Information from a Speaker to the Mobile Robot Initial Position . . . . .	274
8.6	Definition of the Probabilistic Audio Visual Attention Mobile Robot Model in the Steps of the Mobile Robot Navigation Algorithm. . . . .	276

- 8.7 Experimental Results from the Simulations of the Mobile Robot Motion Navigation Algorithm Applying the Probabilistic Audio Visual Attention Model. . . . . 279
  - 8.7.1 Experimental Results from the Simulations of the Mobile Robot Motion Navigation Algorithm Applying Visual Perception Only . . . . . 280
  - 8.7.2 Experimental Results from the Simulations of the Mobile Robot Motion Navigation Algorithm Using Visual Attention in Combination with the Visual Perception. . . . . 282
  - 8.7.3 Quantitative Comparison of the Simulations Results Applying Visual Perception Only, and Visual Attention with Visual Perception . . . . . 283
  - 8.7.4 Experimental Results from Simulations Using Audio Visual Attention in Combination with Audio Visual Perception . . . . . 285
  - 8.7.5 Quantitative Comparison of the Results Achieved in Simulations Applying Audio Visual Perception Only, and Visual Attention Combined with Visual Perception . . . . . 287
- 8.8 Conclusion . . . . . 289
- References . . . . . 291
- 9 Local Adaptive Image Processing . . . . . 295**
  - Rumen Mironov
  - 9.1 Introduction. . . . . 296
  - 9.2 Method for Local Adaptive Image Interpolation. . . . . 297
    - 9.2.1 Mathematical Description of Adaptive 2D Interpolation. . . . . 297
    - 9.2.2 Analysis of the Characteristics of the Filter for Two-Dimensional Adaptive Interpolation . . . . . 298
    - 9.2.3 Evaluation of the Error of the Adaptive 2D Interpolation . . . . . 302
    - 9.2.4 Functional Scheme of the 2D Adaptive Interpolator . . . . . 305
  - 9.3 Method for Adaptive 2D Error Diffusion Halftoning. . . . . 306
    - 9.3.1 Mathematical Description of Adaptive 2D Error-Diffusion . . . . . 306
    - 9.3.2 Determining the Weighting Coefficients of the 2D Adaptive Halftoning Filter . . . . . 308
    - 9.3.3 Functional Scheme of 2D Adaptive Halftoning Filter. . . . . 309
    - 9.3.4 Analysis of the Characteristics of the 2D Adaptive Halftoning Filter. . . . . 311

- 9.4 Method for Adaptive 2D Line Prediction of Halftone Images. . . . . 314
  - 9.4.1 Mathematical Description of Adaptive 2D Line Prediction . . . . . 314
  - 9.4.2 Synthesis and Analysis of Adaptive 2D LMS Codec for Linear Prediction. . . . . 316
- 9.5 Experimental Results . . . . . 320
  - 9.5.1 Experimental Results from the Work of the Developed Adaptive 2D Interpolator . . . . . 320
  - 9.5.2 Experimental Results from the Work of the Developed Adaptive 2D Halftoning Filter . . . . . 325
  - 9.5.3 Experimental Results from the Work of the Developed Codec for Adaptive 2D Linear Prediction . . . . . 326
- 9.6 Conclusion . . . . . 328
- References . . . . . 329
- 10 Machine Learning Techniques for Intelligent Access Control . . . . . 331**

Wael H. Khalifa, Mohamed I. Roushdy and Abdel-Badeeh M. Salem

  - 10.1 Introduction. . . . . 331
  - 10.2 Machine Learning Methodology for Biometrics . . . . . 333
    - 10.2.1 Signal Capturing . . . . . 333
    - 10.2.2 Feature Extraction . . . . . 334
    - 10.2.3 Classification . . . . . 334
  - 10.3 User Authentication Techniques. . . . . 335
  - 10.4 Physiological Biometrics Taxonomy. . . . . 336
    - 10.4.1 Finger Print. . . . . 336
    - 10.4.2 Face . . . . . 337
    - 10.4.3 Iris . . . . . 337
  - 10.5 Behavioral Biometrics Taxonomy. . . . . 339
    - 10.5.1 Keystroke Dynamics. . . . . 339
    - 10.5.2 Voice . . . . . 340
    - 10.5.3 EEG. . . . . 340
  - 10.6 Multimodal Biometrics . . . . . 341
  - 10.7 Applications . . . . . 342
  - 10.8 Machine Learning Techniques for Biometrics . . . . . 343
    - 10.8.1 Fisher’s Discriminant Analysis. . . . . 343
    - 10.8.2 Linear Discriminant Classifier . . . . . 345
    - 10.8.3 LVQ Neural Net . . . . . 346
    - 10.8.4 Neural Networks . . . . . 347
  - 10.9 Conclusion . . . . . 349
  - References . . . . . 351

- 11 Experimental Evaluation of Opportunity to Improve the Resolution of the Acoustic Maps . . . . . 353**  
Volodymyr Kudriashov
- 11.1 Introduction. . . . . 353
- 11.2 Theoretical Part . . . . . 354
  - 11.2.1 Signal Model Limitations . . . . . 354
  - 11.2.2 Signal Model. . . . . 355
  - 11.2.3 Acoustic Mapping Methods . . . . . 357
- 11.3 The Experimental Acoustic Camera Equipment . . . . . 359
- 11.4 Experimental Results . . . . . 361
  - 11.4.1 Microphone Array Patterns Generated with the Delay-and-Sum Beamforming Method . . . . . 362
  - 11.4.2 Microphone Array Patterns Generated with the Christensen Beamforming Method . . . . . 363
  - 11.4.3 Microphone Array Patterns Generated with the Modified Capon-Based Beamforming Method . . . . . 365
  - 11.4.4 Microphone Array Responses for Two Point-like Emitters . . . . . 368
  - 11.4.5 The Acoustic Camera Responses for Two Point-like Emitters . . . . . 371
- 11.5 Conclusions . . . . . 372
- References . . . . . 373



<http://www.springer.com/978-3-319-32190-5>

New Approaches in Intelligent Image Analysis  
Techniques, Methodologies and Applications

Kountchev, R.; Nakamatsu, K. (Eds.)

2016, XX, 373 p. 157 illus., 119 illus. in color.,  
Hardcover

ISBN: 978-3-319-32190-5