

**DIGITAL IMAGE  
PROCESSING  
ALGORITHMS  
AND  
APPLICATIONS**



**I. Pitas**



# Contents

<i>Preface</i>	<i>ix</i>
<b>1</b> <i>Digital image processing fundamentals</i>	<b>1</b>
1.1 <i>Introduction</i>	1
1.2 <i>Topics of digital image processing and analysis</i>	2
1.3 <i>Digital image formation</i>	4
1.4 <i>Digital image representation</i>	7
1.5 <i>Elementary digital image processing operations</i>	13
1.6 <i>Digital image display</i>	18
1.7 <i>Fundamentals of color image processing</i>	20
1.8 <i>Noise generators for digital image processing</i>	38
 <i>References</i>	 <i>47</i>
<b>2</b> <i>Digital image transform algorithms</i>	<b>51</b>
2.1 <i>Introduction</i>	51
2.2 <i>Two-dimensional discrete Fourier transform</i>	52
2.3 <i>Row-column FFT algorithm</i>	59
2.4 <i>Memory problems in 2-d DFT calculations</i>	68
2.5 <i>Vector-radix fast Fourier transform algorithm</i>	85

2.6	<i>Polynomial transform FFT</i>	92
2.7	<i>Two-dimensional power spectrum estimation</i>	96
2.8	<i>Discrete cosine transform</i>	103
2.9	<i>Two-dimensional discrete cosine transform</i>	107
2.10	<i>Discrete wavelet transform</i>	113
<i>References</i>		117
3	<i>Digital image filtering and enhancement</i>	121
3.1	<i>Introduction</i>	121
3.2	<i>Direct implementation of two-dimensional FIR digital filters</i>	122
3.3	<i>Fast Fourier transform implementation of FIR digital filters</i>	125
3.4	<i>Block methods in the linear convolution calculation</i>	128
3.5	<i>Inverse filter implementations</i>	133
3.6	<i>Wiener filters</i>	135
3.7	<i>Median filter algorithms</i>	139
3.8	<i>Digital filters based on order statistics</i>	149
3.9	<i>Signal Adaptive order statistic filters</i>	156
3.10	<i>Histogram and histogram equalization techniques</i>	162
3.11	<i>Pseudocoloring algorithms</i>	166
3.12	<i>Digital image halftoning</i>	168
3.13	<i>Image interpolation algorithms</i>	174
3.14	<i>Anisotropic Diffusion</i>	177
3.15	<i>Image Mosaicing</i>	179
3.16	<i>Image watermarking</i>	180
<i>References</i>		185

4	<i>Digital image compression</i>	191
4.1	<i>Introduction</i>	191
4.2	<i>Huffman coding</i>	192
4.3	<i>Run-length coding</i>	200
4.4	<i>Modified READ coding</i>	203
4.5	<i>LZW compression</i>	205
4.6	<i>Predictive coding</i>	221
4.7	<i>Transform image coding</i>	229

4.8	<i>JPEG2000 compression standard</i>	235
	<i>References</i>	239
5	<i>Edge detection algorithms</i>	241
5.1	<i>Introduction</i>	241
5.2	<i>Edge detection</i>	242
5.3	<i>Edge thresholding</i>	249
5.4	<i>Hough transform</i>	249
5.5	<i>Edge-following algorithms</i>	257
	<i>References</i>	273
6	<i>Image segmentation algorithms</i>	275
6.1	<i>Introduction</i>	275
6.2	<i>Image segmentation by thresholding</i>	277
6.3	<i>Split/merge and region growing algorithms</i>	282
6.4	<i>Relaxation algorithms in region analysis</i>	297
6.5	<i>Connected component labeling</i>	300
6.6	<i>Texture description</i>	303
	<i>References</i>	319
7	<i>Shape description</i>	323
7.1	<i>Introduction</i>	323
7.2	<i>Chain codes</i>	324
7.3	<i>Polygonal approximations</i>	329
7.4	<i>Fourier descriptors</i>	334
7.5	<i>Quadtrees</i>	336
7.6	<i>Pyramids</i>	342
7.7	<i>Shape features</i>	348
7.8	<i>Moment descriptors</i>	352
7.9	<i>Thinning algorithms</i>	356
7.10	<i>Mathematical morphology</i>	361
7.11	<i>Grayscale morphology</i>	369
7.12	<i>Skeletons</i>	372
7.13	<i>Shape decomposition</i>	376
7.14	<i>Voronoi tessellation</i>	382

7.15	<i>Watershed transform</i>	385
7.16	<i>Face detection and recognition</i>	386
<i>References</i>		393
8	<i>Digital Image Processing Lab Exercises Using EIKONA</i>	401
8.1	<i>Introduction</i>	401
8.2	<i>Overview</i>	401
8.3	<i>Structure</i>	402
8.4	<i>BW image processing</i>	405
8.4.1	<i>Black-and-White</i>	405
8.4.2	<i>Basic</i>	405
8.4.3	<i>Processing</i>	405
8.4.4	<i>Analysis</i>	405
8.4.5	<i>Transforms</i>	406
8.4.6	<i>Filtering</i>	406
8.4.7	<i>Nonlinear filtering</i>	406
8.5	<i>Color image processing</i>	406
8.5.1	<i>Basic</i>	406
8.5.2	<i>Processing</i>	407
8.5.3	<i>Analysis</i>	407
8.5.4	<i>Color Representation</i>	407
8.6	<i>Modules</i>	407
8.6.1	<i>Arts module</i>	408
8.6.2	<i>Crack Restoration</i>	410
8.6.3	<i>Watermark module</i>	412
8.7	<i>EIKONA Source, Library/DLL</i>	413
8.8	<i>Instructions for using the educational material</i>	413
<i>References</i>		417
<i>Index</i>		418