Table of contents

1 Introduction

1.1 What is Digital Image Processing?

1.2 The Origins of Digital Image Processing

1.3 Examples of Fields that Use Digital Image Processing

1.4 Fundamental Steps in Digital Image Processing

1.5 Components of an Image Processing System

2 Digital Image Fundamentals

2.1 Elements of Visual Perception

2.2 Light and the Electromagnetic Spectrum

2.3 Image Sensing and Acquisition

2.4 Image Sampling and Quantization

2.5 Some Basic Relationships Between Pixels

2.6 Introduction to the Basic Mathematical Tools Used in Digital Image Process

3 Intensity Transformations and Spatial Filtering

3.1 Background

3.2 Some Basic Intensity Transformation Functions

3.3 Histogram Processing

3.4 Fundamentals of Spatial Filtering

3.5 Smoothing (Lowpass) Spatial Filters

3.6 Sharpening (Highpass) Spatial Filters

3.7 Highpass, Bandreject, and Bandpass Filters from Lowpass Filters

3.8 Combining Spatial Enhancement Methods

4 Filtering in the Frequency Domain

4.1 Background

4.2 Preliminary Concepts

4.3 Sampling and the Fourier Transform of Sampled Functions

4.4 The Discrete Fourier Transform of One Variable

4.5 Extensions to Functions of Two Variables

4.6 Some Properties of the 2-D DFT and IDFT

4.7 The Basics of Filtering in the Frequency Domain

4.8 Image Smoothing Using Lowpass Frequency Domain Filters

4.9 Image Sharpening Using Highpass Filters

4.10 Selective Filtering

4.11 The Fast Fourier Transform

5 Image Restoration and Reconstruction

5.1 A Model of the Image Degradation/Restoration Process

5.2 Noise Models

5.3 Restoration in the Presence of Noise Only-Spatial Filtering

5.4 Periodic Noise Reduction Using Frequency Domain Filtering

5.5 Linear, Position-Invariant Degradations

5.6 Estimating the Degradation Function

5.7 Inverse Filtering

5.8 Minimum Mean Square Error (Wiener) Filtering

5.9 Constrained Least Squares Filtering

5.10 Geometric Mean Filter

5.11 Image Reconstruction from Projections

6 Color Image Processing

6.1 Color Fundamentals

6.2 Color Models

6.3 Pseudocolor Image Processing

6.4 Basics of Full-Color Image Processing

6.5 Color Transformations

6.6 Color Image Smoothing and Sharpening

6.6 Using Color in Image Segmentation

6.8 Noise in Color Images

6.9 Color Image Compression

7 Wavelet and Other Image Transforms

7.1 Preliminaries

7.2 Matrix-based Transforms

7.3 Correlation

7.4 Basis Functions in the Time-Frequency Plane

7.5 Basis Images

7.7 Fourier-Related Transforms

7.7 Walsh-Hadamard Transforms

7.8 Slant Transform

7.9 Haar Transform

7.10 Wavelet Transforms

8 Image Compression and Watermarking

8.1 Fundamentals

8.2 Huffman Coding

8.3 Golomb Coding

8.4 Arithmetic Coding

8.5 LZW Coding

8.6 Run-length Coding

8.7 Symbol-based Coding

8.8 Bit-plane Coding

8.9 Block Transform Coding

8.10 Predictive Coding

8.11 Wavelet Coding

8.12 Digital Image Watermarking

9 Morphological Image Processing

9.1 Preliminaries

9.2 Erosion and Dilation

9.3 Opening and Closing

9.4 The Hit-or-Miss Transform

9.5 Some Basic Morphological Algorithms

9.6 Morphological Reconstruction

9.7 Summary of Morphological Operations on Binary Images

9.8 Grayscale Morphology

10 Image Segmentation

10.1 Fundamentals

10.2 Point, Line, and Edge Detection

10.3 Thresholding

10.4 Segmentation by Region Growing and by Region Splitting and Merging

10.5 Region Segmentation Using Clustering and Superpixels

10.6 Region Segmentation Using Graph Cuts

10.7 Segmentation Using Morphological Watersheds

10.8 The Use of Motion in Segmentation

11 Feature Extraction

11.1 Background

11.2 Boundary Preprocessing

11.3 Boundary Feature Descriptors

11.4 Region Feature Descriptors

11.5 Principal Components as Feature Descriptors

11.6 Whole-Image Features

11.7 Scale-Invariant Feature Transform (SIFT)

12 Image Pattern Classification

12.1 Background

12.2 Patterns and Pattern Classes

12.3 Pattern Classification by Prototype Matching

12.4 Optimum (Bayes) Statistical Classifiers

12.5 Neural Networks and Deep Learning

12.6 Deep Convolutional Neural Networks

12.7 Some Additional Details of Implementation

Bibliography

Index