Preface

Vision is the most powerful of the five human senses. Visual information, conveyed in the form of images gives better impact than textual information. The fields of digital image processing have grown tremendously over the past 30 years. The growth of digital image processing has been fueled by technological advances in digital imaging, computer processors and mass storage devices. Research and development of image processing technologies have advanced very rapidly in the past decade. Digital image processing is concerned primarily with the extraction of useful information from images. In this process, it also deals with 1) image representation, 2) enhancing the quality of an image, 3) restoration of the original image from its degraded version, and 4) compression of the large amount of data in the images for efficient archiving and retrieval. Image-processing algorithms can be classified into three different categories. At the lowest level, the algorithm deals directly with the raw pixel values (image denoising and edge detection are good examples). In the middle level, the algorithm utilises low-level results for processes such as segmentation and edge linking. At the highest level, the algorithm attempts to extract semantic information from those provided by the lower levels. Examples of high-level algorithms are handwriting recognition, face recognition and machine vision algorithms. The objective of this book is to not only introduce different concepts of digital image processing to undergraduate and postgraduate students but also to serve as a handbook for practicing engineers.

Simulation is an essential tool in any field related to engineering techniques. In this book, the image-processing algorithms are simulated using MATLAB. It has been the endeavour of the authors to present a large number of detailed worked examples to illustrate the various digital image-processing concepts.

Organisation of the Book

This book contains twelve chapters. ***Chapter* 1** gives an overview of the digital image-processing system. The different elements of image-processing systems like image acquisition, image sampling, quantisation, image sensors, image scanners and image storage devices are covered in this chapter. The highlight of this chapter is the discussion of the different types of image file formats in practice.

Chapter 2 deals with two-dimensional signals and systems. Different types of two-dimensional signals, and properties of two-dimensional signals like separability and periodicity are discussed in this chapter. This chapter also gives an overview of the two-dimensional system. The focus is mainly on the linear shift-invariant system. As Z-transform is widely used to analyse two dimensional signals and systems, the understanding of the 2D signals and systems is enriched through numerous examples of forward and inverse two-dimensional Z transforms in this chapter.

Chapter 3 is devoted to 2D convolution and correlation. Convolution is one of the most powerful mathematical operators which is widely used in the field of digital image processing. In this chapter, the computation of 2D convolution and correlation using graphical, matrix and Z-transform methods are discussed in a step-by-step approach. The examples related to 2D convolution and correlations are illustrated through MATLAB examples.

The focus in ***Chapter 4*** is on image transforms. The need for image transforms, different types of image transforms and their properties are explained in this chapter. The image transforms discussed in this chapter include two-dimensional Fourier transform, Walsh transform, Hadamard transform, Slant transform, KL transform, Discrete Cosine Transform, Radon transform and Singular Value Decomposition.

Chapter 5 discusses different techniques employed for the enhancement of images. This chapter includes techniques in spatial as well as frequency domains. While the frequency domain methods discuss the design of low-pass, high-pass and band-pass filters, the discussion of techniques related to the spatial domain include different gray-level transformations together with spatial filtering methods such as low-pass, high-pass and high boost filtering which are illustrated with MATLAB examples. Further, in this chapter, certain test images like flowers, animals and popular monuments are considered rather than the usual images, like Cameraman and Lena, to bring out variety and emphasis on generality in approach.

Chapter 6 provides an overview of image restoration and image denoising techniques. The different causes for image degradation, and deterministic and stochastic methods of image restoration are the crucial topics that are discussed in this chapter. Also, this chapter covers the different types of image denoising techniques like average filtering, median filtering, alpha-trimmed filtering and min-max filtering.

Chapter 7 deals with different techniques in image segmentation. The different techniques include region, boundary and edge-based segmentation methods. Advanced image segmentation algorithms like the Snake algorithm and Watershed algorithm are covered in this chapter.

Chapter 8 gives an overview of different types of object-recognition techniques. Different types of representation of patterns are discussed in this chapter, namely Statistical approach, Structural approach and Neural-Network approach. Different applications of object recognition are also discussed in this chapter.

Chapter 9 is devoted to image compression. The need for image compression, spatial domain and frequency domain techniques of image compression and the applications of image compression form the heart of this chapter. One of the powerful tools to achieve compression is vector quantisation. This chapter gives the basic idea of vector quantisation (VQ) and different approaches to VQ through illustrative examples.

Chapter 10 deals with binary image processing. In this chapter, different morphological operations like dilation, erosion, opening and closing are given with suitable MATLAB examples along with their properties. Other topics discussed in this chapter include thinning, thickening, distance transform and hit-or-miss transform.

The concepts related to colour image processing are given in ***Chapter 11***. The concepts discussed in this chapter include human perception of colour, colour models, colour image quantisation, colour image filtering, pseudo-colouring, colour image histogram and colour image segmentation.

Finally, in ***Chapter 12***, the application of wavelets in image processing are dealt with. The different wavelet-based applications considered in this chapter are image compression, image denoising and watermarking. The embedded quantisation techniques widely used in the field of image compression like EZW and SPIHT are explained through numerical examples. An introduction to advanced concepts like multi-wavelet transforms, contourlet transforms and directional filter banks are also given in this chapter to provide some sense of completeness and stimulate the researchers' interest.

Each chapter is equipped with a set of solved problems with solutions, and review questions with answers. The problem sets help readers to understand the basic concepts in digital image processing.

In addition to the twelve chapters, four appendices are also given in this book. Since MATLAB has been used extensively to highlight the various concepts throughout this book, a list of commonly used MATLAB commands in image processing are provided in ***Appendix I***.

From our past teaching experience, it is the considered opinion of the authors that a holistic picture of Image Transforms can be brought about by providing a unified treatment from the standpoint of vector spaces. An introductory knowledge related to Vector Space, thus, becomes essential to the understanding of image transforms. An introduction to Vector Spaces is provided in ***Appendix II***.

A digital image can be represented in terms of a matrix. Hence, a basic knowledge of matrices will be useful for effective manipulation of images. Fundamental concepts related to different types of matrices are given in ***Appendix III***.

Objective-type questions measure one's ability to remember facts and figures and comprehend the concepts related to any subject. In this book, a rich set of objective-type questions along with answers are separately provided in ***Appendix IV***.

Apart from this, the book also has additional web supplements and an accompanying CD. The online contents can be accessed at http://www.mhhe.com/jayaraman/dip and contain the following material:

- **An Introduction to Video Processing**
  - Introduction to video processing
  - Spatio-temporal sampling
  - Interframe and Intraframe coding
  - Motion Estimation Techniques
  - Video Compression Standards
- **Interactive Quiz**
- **Downloadable images from the text**
- **Solution Manual for Instructors**
- **The accompanying CD contains**
  - Powerpoint tutorials
  - Images from the text
  - MATLAB codes

We earnestly hope that this book will initiate many persons to the exciting world of digital image processing. Though we have spared no pains to make this book free from mistakes, some errors may still have survived our scrutiny. We gladly welcome all corrections, recommendations, suggestions and constructive criticism from our readers.

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