

# Digital Image Processing

D. Sundararajan

# Digital Image Processing

A Signal Processing and Algorithmic  
Approach



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# Preface

Vision is one of our strongest senses. The amount of information conveyed through pictures over the Internet and other media is enormous. Therefore, the field of image processing is of great interest and rapidly growing. Availability of fast digital computers and numerical algorithms accelerates this growth. In this book, the basics of *Digital Image Processing* is presented, using a signal processing and algorithmic approach. The image is a two-dimensional signal, and most processing requires algorithms. Plenty of examples, figures, tables, programs, and physical explanations make it easy for the reader to get a good grounding in the basics of the subject, able to progress to higher levels, and solve practical problems.

The application of image processing is important in several areas of science and engineering. Therefore, *Digital Image Processing* is a field of study for engineers and computer science professionals. This book includes mathematical theory, basic algorithms, and numerical examples. Thereby, engineers and professionals can quickly develop algorithms and find solutions to image processing problems of their interest using computers. In general, there is no formula for solving practical problems. Invariably, an algorithm has to be developed and used to find the solution. While every solution is a combination of the basic principles, several combinations are possible for solving the same problem. Out of these possibilities, one has to come with the right solution. This requires some trial-and-error process. A good understanding of the basic principles, knowledge of the characteristics of the image data involved, and practical experience are likely to lead to an efficient solution.

This book is intended to be a textbook for senior undergraduate- and graduate-level *Digital Image Processing* courses in engineering and computer science departments and a supplementary textbook for application courses such as remote sensing, machine vision, and medical analysis. For image processing professionals, this book will be useful for self-study. In addition, this book will be a reference for anyone, student or professional, specializing in image processing. The prerequisite for reading this book is a good knowledge of calculus, linear algebra, one-dimensional digital signal processing, and programming at the undergraduate level.

Programming is an important component in learning and practicing this subject. A set of MATLAB<sup>®</sup> programs are available at the Web site of the book. While the use of a software package is inevitable in most applications, it is better to use the software in addition to self-developed programs. The effective use of a software package or to develop own programs requires a good grounding in the basic principles of the subject. Answers to selected exercises marked \* are given at the end of the book. A Solutions Manual and slides are available for instructors at the Web site of the book.

I assume the responsibility for all the errors in this book and would very much appreciate receiving readers' suggestions and pointing out any errors (email:d\_sundararajan@yahoo.com). I am grateful to my Editor and the rest of the team at Springer for their help and encouragement in completing this project. I thank my family for their support during this endeavor.

D. Sundararajan

# About the Book

This book “Digital Image Processing—A Signal Processing and Algorithmic Approach” deals with the fundamentals of *Digital Image Processing*, a topic of great interest in science and engineering. *Digital Image Processing* is processing of images using digital devices after they are converted to a 2-D matrix of numbers. While the basic principles of the subject are those of signal processing, the applications require extensive use of algorithms. In order to meet these requirements, the book presents the mathematical theory along with numerical examples with  $4 \times 4$  and  $8 \times 8$  subimages. The presentation of the mathematical aspects has been greatly simplified with sufficient detail. Emphasis is given for physical explanation of the mathematical concepts, which will result in deeper understanding and easier comprehension of the subject. Further, the corresponding MATLAB codes are given as supplementary material. The book is primarily intended as a textbook for an introductory *Digital Image Processing* course at senior undergraduate and graduate levels in engineering and computer science departments. Further, it can be used as a reference by students and practitioners of *Digital Image Processing*.

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## About the Author

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# Abbreviations

1-D	One-dimensional
2-D	Two-dimensional
3-D	Three-dimensional
bpp	Bits per pixel
DC	Sinusoid with frequency zero, constant
DFT	Discrete Fourier transform
DWT	Discrete wavelet transform
FIR	Finite impulse response
FT	Fourier transform
IDFT	Inverse discrete Fourier transform
IDWT	Inverse discrete wavelet transform
IFT	Inverse Fourier transform
LoG	Laplacian of Gaussian
LSB	Least significant bit
MSB	Most significant bit
PCA	Principal component analysis
SNR	Signal-to-noise ratio