The Essential Guide to

Image Processing

AL BOVIK

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The Essential Guide to Image Processing

Second Edition

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Preface

The visual experience is the principal way that humans sense and communicate with their world. We are visual beings and images are being made increasing available to us in electronic digital format via digital cameras, the internet, and hand-held devices with large-format screens. With much of the technology being introduced to the consumer marketplace being rather new, digital image processing remains a "hot" topic and promises to be one for a very long time. Of course, digital image processing has been around for quite awhile, and indeed, methods pervade nearly every branch of science and engineering. One only has to view the latest space telescope images or read about the newest medical image modality to be aware of this.

With this introduction, welcome to *The Essential Guide to Image Processing*! The reader will find that this *Guide* covers introductory, intermediate and advanced topics of digital image processing, and is intended to be highly accessible for those entering the field or wishing to learn about the topic for the first time. As such, the *Guide* can be effectively used as a classroom textbook. Since many intermediate and advanced topics are also covered, the *Guide* is a useful reference for the practicing image processing engineer, scientist, or researcher. As a learning tool, the *Guide* offers easy-to-read material at different levels of presentation, including introductory and tutorial chapters on the most basic image processing techniques. Further, there is included a chapter that explains digital image processing software that is included on a CD with the book. This software is part of the award-winning *SIVA* educational courseware that has been under development at The University of Texas for more than a decade, and which has been adopted for use by more than 400 educational, industry, and research institutions around the world. Image processing educators are invited these user-friendly and intuitive live image processing demonstrations into their teaching curriculum.

The *Guide* contains 27 chapters, beginning with an introduction and a description of the educational software that is included with the book. This is followed by tutorial chapters on the basic methods of gray-level and binary image processing, and on the essential tools of image Fourier analysis and linear convolution systems. The next series of chapters describes tools and concepts necessary to more advanced image processing algorithms, including wavelets, color, and statistical and noise models of images. Methods for improving the appearance of images follow, including enhancement, denoising and restoration (deblurring). The important topic of image compression follows, including chapters on lossless compression, the JPEG and JPEG-2000 standards, and wavelet image compression. Image analysis chapters follow, including two chapters on edge detection and one on the important topic of image quality assessment. Finally, the *Guide* concludes with six exciting chapters dealing explaining image processing applications on such diverse topics as image watermarking, fingerprint recognition, digital microscopy, face recognition, and digital tomography. These have been selected for their timely interest, as well as their illustrative power of how image processing and analysis can be effectively applied to problems of significant practical interest.

The *Guide* then concludes with a chapter pointing towards the topic of digital *video* processing, which deals with visual signals that vary over time. These very broad and more advanced field is covered in a companion volume suitably entitled *The Essential Guide to Video Processing.* The topics covered in the two companion *Guides* are, of course closely related, and it may interest the reader that earlier editions of most of this material appeared in a highly popular but gigantic volume known as *The Handbook of Image and Video Processing.* While this previous book was very well-received, its sheer size made it highly un-portable (but a fantastic doorstop). For this newer rendition, in addition to updating the content, I made the decision to divide the material into two distinct books, separating the material into coverage of still images and moving images (video). I am sure that you will find the resulting volumes to be information-rich as well as highly accessible.

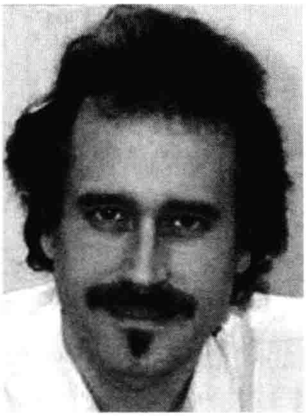
As Editor and Co-Author of *The Essential Guide to Image Processing,* I would thank the many co-authors who have contributed such wonderful work to this *Guide.* They are all models of professionalism, responsiveness, and patience with respect to my cheerleading and cajoling. The group effort that created this book is much larger, deeper, and of higher quality than I think that any individual could have created. Each and every chapter in this *Guide* has been written by a carefully selected distinguished specialist, ensuring that the greatest depth of understanding be communicated to the reader. I have also taken the time to read each and every word of every chapter, and have provided extensive feedback to the chapter authors in seeking to perfect the book. Owing primarily to their efforts, I feel certain that this *Guide* will prove to be an essential and indispensable resource for years to come.

I would also like to thank the staff at Elsevier—the Senior Commissioning Editor, Tim Pitts, for his continuous stream of ideas and encouragement, and for keeping after me to do this project; Melanie Benson for her tireless efforts and incredible organization and accuracy in making the book happen; Eric DeCicco, the graphic artist for his efforts on the wonderful cover design, and Greg Dezarn-O'Hare for his flawless typesetting.

National Instruments, Inc., has been a tremendous support over the years in helping me develop courseware for image processing classes at The University of Texas at Austin, and has been especially generous with their engineer's time. I particularly thank NI engineers George Panayi, Frank Baumgartner, Nate Holmes, Carleton Heard, Matthew Slaughter, and Nathan McKimpson for helping to develop and perfect the many Labview demos that have been used for many years and are now available on the CD-ROM attached to this book.

Al Bovik
Austin, Texas
April, 2009

About the Author



Al Bovik currently holds the Curry/Cullen Trust Endowed Chair Professorship in the Department of Electrical and Computer Engineering at The University of Texas at Austin, where he is the Director of the Laboratory for Image and Video Engineering (LIVE). He has published over 500 technical articles and six books in the general area of image and video processing and holds two US patents.

Dr. Bovik has received a number of major awards from the IEEE Signal Processing Society, including the Education Award (2007); the Technical Achievement Award (2005), the Distinguished Lecturer Award (2000); and the Meritorious Service Award (1998). He is also a recipient of the IEEE Third Millennium Medal (2000), and has won two journal paper awards from the Pattern Recognition Society (1988 and 1993). He is a Fellow of the IEEE, a Fellow of the Optical Society of America, and a Fellow of the Society of Photo-Optical and Instrumentation Engineers. Dr. Bovik has served Editor-in-Chief of the *IEEE Transactions on Image Processing* (1996–2002) and created and served as the first General Chairman of the *IEEE International Conference on Image Processing*, which was held in Austin, Texas, in 1994.

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