Thomas M. Deserno (ed): *Biomedical Image Processing*

Springer-Verlag Berlin Heidelberg, ISBN 978-3-642-15815-5

e-ISBN 978-3-642-13813-2, published in 2011

Janice Honeyman-Buck

Published online: 24 October 2012

© Society for Imaging Informatics in Medicine 2012

Fig. 1 *Biomedical Image Processing*

Medical and biomedical image processing textbooks have been published over the years; many of which are not comprehensible for anyone other than expert image processing researchers. The leadership of the International SPIE Symposium on Medical Imaging and the Springer-Verlag Series Editor of Biological and Medical Physics, Medical Engineering recognized the

need for a textbook that could be used by both novices and experts to advance the field. They contacted Thomas Deserno with the idea of expanding some of the topics presented at the International SPIE Symposium on Medical Imaging to compile a book. He convinced 47 researchers, scientists, and graduate students to write chapters for the book *Biomedical Image Processing* (Fig. 1). He edited each chapter so the book has a uniform appearance, not a collection of individual papers, and contains useful information for anyone interested in medical and biomedical image processing. I am not an expert in this field and found myself entranced with the clear and concise definitions and descriptions of image processing techniques. This should be a reference for anyone in the field from the certified imaging informatics professionals to the interested imaging technologists, students, radiologists, scientists, and researchers.

The book is organized into eight parts with about three chapters in each part. The parts are shown in Table 1. Each chapter begins with a summary of the chapter followed by an introduction to the topic of the chapter and then continues with increasing detail. Illustrations and figures are often in full color and of extremely high quality. I will not attempt to extensively review each of the 22 chapters and instead will focus on an overview of each of the eight sections and the leading chapter.

The first chapter, Fundamentals of Biomedical Image Processing by Thomas Deserno, could stand on its own as a teaching tool and introduction to the topic. This comprehensive chapter describes the formation of images, enhancement, data visualization, visual feature extraction, segmentation, classification, measurements and interpretation, and image management. He gives the reader a concise description of how images are formed using X-ray imaging, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound (US), and digitalization. He takes us

J. Honeyman-Buck (✉)
508 Bramble Fern Ave,
DeLand, FL 32720, USA
e-mail: honeymanbuck@aol.com

Table 1 Parts or sections contained in the book *Biomedical Image Processing*

1	Image formation
2	Image enhancement
3	Feature extraction and selection
4	Segmentation
5	Classification and measurements
6	Image data visualization
7	Image manipulation and integration
8	Evaluation and customizing

through the fundamentals of image enhancement describing tools that are often available to anyone using display software, but may not have been understood. Feature extraction such as vessels extracted from a vascular study is described. Segmentation is defined and illustrated with CT, microscopy, and X-ray images. Classification is illustrated in the use of calculating bone age and dental fixtures using X-ray images. The processes included in a Picture Archiving and Communication System (PACS) are described in the image management section.

Part 1 covers image formation using two of the newer technologies, the Fusion of PET and MRI for Hybrid Imaging and one on Cardiac 4D Ultrasound Imaging. In the first case (chapter 2), the authors provide a description of positron emission tomography (PET) and MRI, then describe the fusion processes, systems, and algorithms. In the second case (chapter 3), the authors describe the roll of US in cardiology, then go on to develop the concepts of 2D, 3D, and 4D principles, limitations, and utilization.

Part 2, Image Enhancement, includes two chapters on Morphological Image Processing Applied in Biomedicine and Medical Image Registration. In the first case, the authors describe the use of mathematical morphology for filtering, segmentation, and pattern matching and pay special attention to morphological reconstruction. In Medical Image Registration (chapter 5), the authors focus on the three key components of image registration algorithms, transformation models, similarity measures, and optimization.

Feature Extraction and Selection (part 3) contains three chapters on Texture in Biomedical Images, Multi-Scale and Multi-Orientation Medical Image Analysis, and Feature extraction and Selection for Decision Making. These technically challenging chapters are richly illustrated to demonstrate the topics covered.

Part 4 continues with more technical chapters on Segmentation with three chapters on Parametric and Non-Parametric Clustering for Segmentation, Region-Based Segmentation; Fuzzy Connectedness, Graph Cut and Related Algorithms, and Model-Based Segmentation. The first article (chapter 9) defines the difference between general image segmentation where the context

of the image is not well defined and may contain shadows and other confounding features and biomedical image segmentation where the context is very well defined, but segmentation of the anatomic region from the background is difficult due to poor imaging statistics. The chapter goes on to describe methods for segmentation and visualization. This leads into chapter 10 where fuzzy connectedness and other segmentation algorithms are covered. The last chapter in this part describes model-based segmentation with the basic concepts and different approaches. Two methods are covered in more detail: deformable simplex meshes and point-based statistical shape models.

Part 5, Classification and Measurements, covers the use of imaging in computer-assisted diagnosis and analysis for the development of therapy. The three chapters included are Melanoma Diagnosis, using dermoscopic images, CADx Mammography using breast imaging, and Quantitative Medical Image Analysis for Clinical Development of Therapeutics using CT, MRI, US, PET, and single photon emission computed tomography. I found the last of these chapters to be especially informative with excellent illustrations, many in color, to illustrate the use of imaging in the assessment of osteoarthritis, carotid atherosclerosis, and cancer.

Part 6, Image Data Visualization, focuses on the Visualization and Exploration of Segmented Anatomic Structures and Processing and Visualization of Diffusion MRI in its two chapters. Chapter 15 covers volume rendering, surface modeling, visualization of vascular structures, and virtual endoscopy and their relevance to clinical radiology. Again, stunning figures are used to illustrate the techniques and results. Diffusion MRI provides the ability to noninvasively investigate neural architecture by using the magnetic field to induce the movement of water while cell membranes, fibers, or other macromolecules hinder the movement. By varying the direction and strength of the magnetic field, the water molecules are used as probes to see the local tissue structure. While somewhat technical, this chapter is an interesting read.

Part 7, Image Management and Integration, contains topics that were the basis of the early development of the Radiology Information Systems Consortium, the Society for Computer-Assisted Radiography, the Society for Imaging Informatics in Medicine, and the *Journal of Digital Imaging*. The three chapters in part 7 include Digital Imaging and Communications in Medicine, an overview of DICOM, PACS-Based Computer-Aided Detection and Diagnosis, including an introduction to CAD-PACS integration, how the DICOM standard, and IHE workflow profiles enable the integration, a CAD-PACS Toolkit, and an example of CAD-PACS integration, and

finally Content-Based Medical Image Retrieval (CBIR). The 19th chapter on CBIR covers the history of the techniques, methods for retrieval, specific medical image retrieval, examples of medical CBIR systems, and a gap analysis of medical CBIR.

Finally, part 8, Evaluation and Customization, includes three chapters on Systematic Evaluations and Ground Truth, Toolkits and Software for Developing Biomedical Image Processing and Analysis Applications, and Image Processing and the Performance Gap. In chapter 20, the authors present the case for evaluation of the effectiveness of proposed algorithms for segmentation, classification, registration, and retrieval prior to introducing them into clinical practice. Methods for completing successful evaluations including establishing ground truth, applying appropriate metrics, and obtaining resources for the study are discussed. The authors present examples of successful evaluation campaigns. This chapter should inspire developers of algorithms to prove that their method is better than previous similar work. Chapter 21 focuses on available toolkits for developing new image processing and analysis including the National Alliance for Medical Image Computing kit, the Insight Segmentation and Registration Toolkit, the Visualization Toolkit, the Medical Imaging Interaction Toolkit, the Medical Imaging Toolkit, Open Multimod Application Framework, and several others. These toolkits usually require high-level programming expertise, but offer modules or reusable code to execute common tasks. The authors also cover extensible software—software that an end-user could use to accomplish visualization and medical image computing tasks.

Examples include OsiriX, ParaView, ImageJ, VolView, and Analyze. The final chapter in the book explains the performance gap in image processing or why the tools developed for medical image processing are not usually widely used in a clinical practice. They define the most common clinically useful image processing applications as windowing and image display, contrast and edge enhancement, noise reduction and color coding, registration and segmentation especially in the fusion of multimodality images, and image compression and management. They hypothesize that the reasons why more sophisticated software has not been accepted in a typical medical imaging clinical practice are the conservative radiologist who may not be willing to interpret images that have been altered and the busy radiologist who has had to absorb the jobs previously performed by the film library clerk (hanging films) and the transcriptionist and does not have time to experiment with new software or processing. Increasing malpractice claims have created the wary radiologist who may have concerns about using anything that potentially alters the image in some way that is not widely used in the radiology community. Finally, the skeptical radiologist may want to see the evidence for using a new process to enhance the clinical practice of radiology.

Overall, this book is a rich and valuable compendium of chapters that cover the current art in biomedical image processing. This is a reference book or textbook for imaging informatics professionals, radiologists, physicists, researchers, scientists, and students interested in the rapidly changing world of imaging and image processing tools and options.