Preface

The spine represents both a vital central axis for the musculoskeletal system and a flexible protective shell surrounding the most important neural pathway in the body, the spinal cord. Spine-related diseases or conditions are common and cause a huge burden of morbidity and cost to society. Examples include degenerative disk disease, spinal stenosis, scoliosis, osteoporosis, herniated disks, fracture/ligamentous injury, infection, tumor, and spondyloarthropathy. Treatment varies with the disease entity and the clinical scenario can be nonspecific.

Spinal imaging via computed tomography (CT), magnetic resonance imaging (MRI), radiography, ultrasound, positron emission tomography (PET), and other radiologic imaging modalities, is essential for noninvasively visualizing and assessing spinal pathology. Computational methods support and enhance the physician's ability to utilize these imaging techniques for diagnosis, noninvasive treatment, and intervention in clinical practice. Algorithms developed in the field of computer vision, computer graphics, signal processing, and machine learning have been adapted to analyze the spinal imaging.

We organize a group of experts in the field of spinal imaging, image analysis, and image guided intervention to contribute their knowledge and insight in this book. The book consists of three parts to cover a broad range of topics encompassing radiological imaging modalities, clinical imaging applications for common spine diseases, image processing, computer-aided diagnosis, quantitative analysis, data reconstruction and visualization, statistical modeling, image-guided spine intervention, and robotic surgery.

Part I of "Clinical Imaging and Applications" focuses on the clinical aspect of this topic. "Imaging of the Spine: A Medical and Physical Perspective" introduces the basic physics of routinely used imaging modalities for visualization of the anatomy and pathology of the spine. The chapter also presents the current paradigm of application in a clinical medical setting. "Arthritis of the Spine" introduces several types of arthritis that commonly affect the spine, including osteoarthritis, degeneration, ankylosing spondylitis, and rheumatoid arthritis. The chapter also provides examples of imaging tools for diagnosing the spinal arthritis, such as radiography and magnetic resonance imaging. "Osteoporosis" introduces another common spine condition, osteoporosis, which affects most in the elder population. The chapter describes diagnostic tools to assess the osteoporotic fracture risk at the spine based on the clinical risk factors and the measurements of bone mineral density by using dual-energy X-ray absorptiometry (DXA) or quantitative CT (QCT).

Part II of "Image Processing" includes ten chapters covering several state-of-art computer techniques to analyze spine images. "Computer Aided Detection of Bone Metastases in the Thoracolumbar Spine" presents a framework for computer-aided detection of lytic and sclerotic metastatic lesions in the thoracolumbar spine using computed tomography. "Quantitative Monitoring of Bone Formation in Ankylosing Spondylitis Using Computed Tomography" presents a system to quantitatively monitor the bone formation in ankylosing spondylitis in a longitudinal study. "Three-Dimensional Spine Reconstruction from Radiographs" describes algorithms to reconstruct 3D spine structure from multiple 2D radiographs. "Vertebral Column Localization, Labeling, and Segmentation" proposes a framework to automatically locate, segment, and label spine column from CT images. "Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images" establishes a spine-based coordinate system for visualization, registration, and planning. "Cross-Modality Vertebrae Localization and Labeling Using Learning-Based Approaches" proposes another approach to localize and label spine column based on machine learning paradigm, and the method can be applied to multiple image modalities. "Articulated Statistical Shape Models of the Spine" presents statistical shape modeling of the spine. The statistical model can be applied in other image processing tasks, such as segmentation and registration. "Reconstruction of 3D Vertebral Models from a Single 2D Lateral Fluoroscopic Image" presents an alternative method to reconstruct the 3D vertebral model from just one single fluoroscopic image using a statistical shape model. "Graphical Model-Based Vertebra Identification from X-Ray Image(s)" describes a method to locate and identify the vertebra on 2D x-ray images based on a graphical model. "Model-Based Segmentation, Reconstruction and Analysis of the Vertebral Body from Spinal CT" is another model-based technique to segment the vertebral body from CTs. A few different approaches are compared.

Part III of "Image Guided Spine Intervention" consists of three chapters that describe the utilization of spine images in surgical planning and procedure. "Toward Virtual Modeling and Templating for Enhanced Spine Surgery Planning" proposes a templating technique for spine surgery planning. "Tracked Ultrasound in Navigated Spine Interventions" presents a tracked ultrasound guided spine surgical navigation system. "Robotic Assistance and Intervention in Spine Surgery" overviews the techniques for robotic assistance in spine intervention.

This is the first book fully dedicated to computational spinal imaging. The goal of this book is to build a bridge between scientists and clinicians in the field of spinal imaging by introducing state-of-art computational methods in the context of clinical applications. Intended readers include imaging scientists interested in clinical applications and clinicians interested in computing techniques. We hope that with this book we raised attention for this important and interesting field of computational spinal imaging and would like to finally thank all contributors for their efforts in making this book possible.

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