Guest Editorial
Special Issue on Spine Imaging, Image-Based Modeling, and Image Guided Intervention

THE vertebral column, also known as backbone or spine, is a bony structure that is formed from individual bones called vertebrae. The spine not only provides physical support to the upper body, but also serves as a protective shell surrounding the most important neural pathway in the body, the spinal cord. Spine related disorders cause a variety of severe problems resulting in huge physical, emotional and economic burdens. Spine-related disorders are amongst the most frequently encountered problems in clinical medicine. For example, chronic lower back pain (due to degenerative spine, disc herniation, etc.) is a serious health problem in the U.S. with more than two million disabled due to back pain.

For diagnosis and treatment support, radiological images such as CT, MRI, and X-ray radiographs are acquired in clinical practice. These images provide not only visual assessment of the spine condition but also quantitative measurement and characterization. Despite the high number of imaging procedures (e.g., 25% of all MRI examinations are performed on spine), computerized image analysis and computer-assisted image-guided interventions of the spine are limited to mostly the research laboratory. Only a few computerized methods are used clinically. The motivation for this special issue is to present the latest advances in technology and raise attention to the crucial role of quantitative imaging in this clinically important field.

This special issue consists of 12 research papers. All submissions underwent a rigorous selection process with at least three reviews from experts in the field. The papers cover a wide range of important topics including novel imaging, computational modeling, automatic vertebra segmentation, as well as computer assisted intervention. Among the 12 papers, nine are related to medical image analysis and three are in the scope of computer assisted intervention. The papers cover a variety of imaging modalities, include CT (five papers), MR (two papers), X-ray (two papers), ultrasound (one paper), and multi-modality (two papers). Sizes of the validation data sets vary from 18 to 12622.

Detailed segmentation of the vertebrae is an important prerequisite in various applications of image-based spine assessment, surgery and biomechanical modeling. This special issue includes eight papers focusing on the segmentation and localization of vertebra, spinal cord and intervertebral discs. For vertebra segmentation, Pereañez *et al.* [1] introduce a part-based statistical decomposition of the vertebra for accurate partition and segmentation of vertebral body and posterior processes on CT. Li *et al.* [2] propose a unified and expendable framework to segment multiple anatomic structures (vertebra and disc) in multiple anatomical planes from multiple imaging modalities (M^3) by formulating the segmentation task as a boundary regression problem. Korez *et al.* [3] describe a framework combining vertebra detection based on interpolation theory and segmentation based on an improved shape-constrained deformable model. Castro-Mateos *et al.* [4] develop a statistical interspace model (SIM) providing interspace information on the interaction of all the individual structures for vertebra segmentation on CT. Cai *et al.* [5] propose a vertebra recognition method using a 3D deformable hierarchical model (DHM) to achieve cross-modality location and pose identification with accurate vertebra labeling, and global 3D spine shape recovery. For spinal cord and canal segmentation, Wang *et al.* [6] propose automatic spinal canal segmentation using probabilistic boosting tree and random walk on CT data from multiple clinical sites. De Leener *et al.* [7] present an automatic segmentation of the spinal cord and canal on different types of MRI sequences and fields of view by combining multi-resolution propagation of tubular deformable models and a vertebral level identification method. For intervertebral disc segmentation, Zheng *et al.* [8] address the problem of fully-automatic localization and segmentation of 3-D intervertebral discs (IVDs) from MR images by data driven estimation and geometric constraints.

Image-guided spine procedures have grown rapidly thanks to the development of both hardware and software. Two papers in this special issue evaluate two of such systems. Fallavollita *et al.* [9] present a unique simulator-based methodology for assessing both technical and nontechnical (cognitive) skills for surgical trainees while immersed in a complete medical simulation environment. Helm *et al.* [10] review a brief history of spinal navigation and summarize the clinical outcome for 12 622 pedicle screws placed using the latest technology in the sacral, lumbar, and thoracic regions.

Patient specific modeling and quantitative measurement play an important role in spine-condition assessment and personalization of spinal intervention. In this special issue, Lekadir *et al.* [11] present a statistical approach for accurate prediction of the vertebral fabric tensors based on a training sample of *ex vivo* micro-CT images. Zheng *et al.* [12] describe a radiation-free freehand 3-D ultrasound system for scoliosis assessment using a volume projection imaging method.

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SHUO LI, *Guest Editor*
Western University and the Digital Imaging Group of London
London, ON, N6A 4V2 Canada

JIANHUA YAO, *Guest Editor*
Department of Radiology and Imaging Sciences Clinical Center
National Institutes of Health
Bethesda, MD USA 20892

NASSIR NAVAB, *Guest Editor*
TU Munich
85748 Munich Germany

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