Principles of magnetic resonance imaging: physics concepts, pulse sequences, & biomedical applications

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Principles of Magnetic Resonance Imaging: Physics Concepts, Pulse Sequences, & Biomedical Applications.
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Publisher: CreateSpace Independent Publishing | Publication Date: October 3, 2012 | ISBN-10: 1479350419 |
www.createspace.com/4001776.

Updated substantially in 2015, as exemplified by additions in Chapter 3.

Figures in ppt files are available:Download.

Principles of Magnetic Resonance Imaging provides a contemporary (2016) introduction to the fundamental concepts of MRI and connects these concepts to the latest MRI developments. Graphic illustrations are used to visualize the complete solution to the Bloch Equation and to clarify underlying biophysical processes, simplified calculations and specific examples are used to add precision in appreciating abstract concepts, and insightful interpretations and clinical examples are presented to appreciate biomedical information in MRI signal. This book contains three parts:

I. Section the body into voxels.
Part I describes the Fourier encoding matrix for an imaging system, realization of Fourier encoding using the gradient field in magnetic resonance, and k-space sampling.

II. What's in a voxel?
Part II examines the effects of the biophysical processes in a voxel on MRI signal. A unified distributional evaluation of the phase factor in a voxel and intuitive biophysical models are developed for MRI signal dependence on Spin fluctuation in a thermal microenvironment, which leads to T1/T2 relaxation rates reflecting cellular contents in a water voxel. Micro- and macro physiological motion, which includes diffusion, perfusion, flow and biomechanical motion. Molecular electron response to the B_0 field, which leads to magnetic susceptibility and chemical shift. The connection of MRI contrast physics to biomedical applications is visualized in the following three terms: 1) cellularity for T2 weighted imaging and diffusion weighted imaging (the latter emphasizing cellular geometry), 2) vascularity for T1 weighted imaging with Gadolinium injection, MR perfusion, and MR angiography, and 3) biomolecularity for MR spectroscopy, and tissue magnetism with emphasis on biometallic imaging.

III. How to operate MRI?
Part III describes MRI safety issues, hardware, software, MRI scanning, and routine MRI protocols.

This MRI book also uses basic concepts to demonstrate and expose students to the latest technological innovations, including: B_{1+} and B_{1-} mapping; Chemical exchange saturation transfer (CEST); Electric property tomography (EPT); Magnetic particle imaging (MPI); MR elastography (MRE); Moving spin tagging including ASL, SPAMM and DENSE; Navigator motion compensation; Parallel or accelerated imaging including SENSE, GRAPPA, compressed sensing and other Bayesian approaches; Quantitative susceptibility mapping (QSM).

QSM (quantitative susceptibility mapping): magnetic resonance imaging of tissue magnetism.
Yi Wang
Publisher: CreateSpace Independent Publishing | Publication Date: July 01, 2013 | ISBN/EAN13: 1490596992 |
www.createspace.com/4346993

Quantitative Susceptibility Mapping gives a systematic account of the fundamentals of physical concepts, technical algorithms, and biomedical applications associated with magnetic resonance imaging of tissue magnetism. Recent progresses in MRI phase analyses and in numerical optimization solvers of inverse problems and promising applications in studying iron and oxygen metabolisms and hemorrhage have attracted many people to investigate quantitative susceptibility mapping (QSM). The objective of this book is to provide a comprehensive and timely introduction for the newly formed and rapidly growing QSM community. Emphasis has been placed on clarity throughout the narrative. Detailed considerations are presented to clarify the subtleties of the physics of magnetism and magnetic resonance signals:

- Thorough demonstrations of the forward problem from magnetic susceptibility to field.
- Comprehensive descriptions of major approaches to solving the field to susceptibility inverse problem.
- Specific examples of clinical and scientific applications.

Engineers, physicists, and clinicians at all levels, from students to established investigators, will find Quantitative Susceptibility Mapping a useful aid in understanding the physical principles of magnetic resonance imaging of tissue magnetic properties.

MRI From Picture to Proton

Donald W. McRobbie, Elizabeth A. Moore, Martin J. Graves, Martin R. Prince

Publisher: Cambridge University Press | Publication Date: March 15, 2007 | ISBN-10: 052168384X | ISBN-13: 978-0521683845 | Edition: 2

MRI from Picture to Proton presents the basics of MR practice and theory in a unique way: backwards! The subject is approached just as a new MR practitioner would encounter MRI: starting from the images, equipment and scanning protocols, rather than pages of physics theory. The reader is brought face-to-face with issues pertinent to practice immediately, filling in the theoretical background as their experience of scanning grows. Key ideas are introduced in an intuitive manner which is faithful to the underlying physics but avoids the need for difficult or distracting mathematics. Additional explanations for the more technically inquisitive are given in optional secondary text boxes. The new edition is fully up-dated to reflect the most recent advances and includes a new chapter on parallel imaging. Informal in style and informed in content, written by recognized effective communicators of MR, this is an essential text for the student of MR.

Read chapter 4 MAGNETIC RESONANCE IMAGING: This cross-disciplinary book documents the key research challenges in the mathematical sciences and physics t... National Research Council. 1996. Mathematics and Physics of Emerging Biomedical Imaging. Washington, DC: The National Academies Press. doi: 10.17226/5066. ×. High-speed imaging pulse sequences, with particular focus on functional imaging, are discussed in this chapter, as are algorithms for image reconstruction; both are promising fields of research. Significant attention is given also to two applications for which MRI has unique potential: blood flow imaging and quantification, and functional neuroimaging based on exploiting dynamic changes in the magnetic susceptibility. Magnetic resonance imaging (MRI) has become a powerful research and clinical imaging tool because compared with CT, MRI can provide non-invasive anatomical, physiological, and functional images at high spatial and temporal resolution with excellent soft tissue contrast; all without the need for ionizing radiation to form the image (Duong, 2010). The soft tissue contrast provided by magnetic resonance imaging (MRI) frequently makes it the modality of choice in oncological imaging. The excellent sensitivity of MRI for detecting lesions is due... A partial list of such extrinsic parameters includes the particular type of image acquisition sequence, the echo time (TE), repetition time (TR), field-of-view, slice thickness, acquisition bandwidth, various saturation and inversion pulses, and resolution. By appropriate manipulation of the extrinsic parameters, an incredibly wide range of image contrasts can be obtained and can be tailored to provide excellent visualization of anatomy, pathology, and, in some cases, function. Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body. MRI scanners use strong magnetic fields, magnetic field gradients, and radio waves to generate images of the organs in the body. MRI does not involve X-rays or the use of ionizing radiation, which distinguishes it from CT and PET scans. MRI is a medical application of nuclear magnetic resonance (NMR) which can also be used for imaging in other