Theory of Quantitative Magnetic Resonance Imaging

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qMRI is a rapidly evolving scientific field of high current interest because it has the potential of radically changing the clinical and research practices of magnetic resonance imaging (MRI). This focuses solely on the theoretical aspects of qMRI, which are treated and analyzed at three different spatial scales, specifically: i) the quantum physics scale of individual spins; ii) the semi-classical physics scale of spin packets; and iii) the imaging scale of voxels. Topics are presented paying particular attention to theoretical unification and mathematical uniformity.

Contents:

- Introduction
- Elements of Imaging Theory
- Physics of Quantitative MRI
- Elements of Relaxation Theory
- QMRI Theory
- QMRI Processing
- Introduction to Applications of QMRI

Readership: Graduate students in physics and biomedical engineering disciplines, engineers and practitioners in biomedical engineering, MRI equipments and image processing industry.

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Magnetic Resonance Imaging (MRI) is a non-invasive imaging technology that produces three dimensional detailed anatomical images. It is often used for disease detection, diagnosis, and treatment monitoring. It is based on sophisticated technology that excites and detects the change in the direction of the rotational axis of protons found in the water that makes up living tissues.Â MRIs employ powerful magnets which produce a strong magnetic field that forces protons in the body to align with that field. When a radiofrequency current is then pulsed through the patient, the protons are stimulated, and spin out of equilibrium, straining against the pull of the magnetic field. â€˜Magnetic Resonance Imaging â€“ Physical Principles and Sequence Designâ€ by Haacke, Brown, Thompson and Venkantesan. Broadly oriented textbook with plenty of physics, techniques and sequences. Not an easily read introduction, but suitable for physicists and similar people. â€œPrinciples of Nuclear Magnetic Resonance Microscopyâ€ by Paul T. Callaghan. A classic within the field of probing molecular dynamics. Technically demanding. Should only be read in the company of a grown-up. â€œSpin Dynamics: Basics of Nuclear Magnetic Resonanceâ€ by Malcolm H. Levitt. Covers theoretical aspects of MR spectroscopy Magnetic resonance imaging (MRI) capable of multiparametric mapping and yielding high soft tissue contrast is widely used for diagnosis, surgical and radiation treatment planning as well as for treatment follow up. In many imaging facilities, perfusion MRI used to map vascular and hemodynamic parameters is part of the neuroimaging protocol, at least for diagnosis and treatment planning.Â In theory, perfusion MRI techniques can yield quantitative hemodynamic parameters. To do so, they rely on a number of assumptions that are detailed below and require additional measurements that are either time consuming or invasive and therefore difficult in the clinical setting.