

PDF DIFFUSION MRI

Diffusion MRI

Diffusion MRI remains the most comprehensive reference for understanding this rapidly evolving and powerful technology and is an essential handbook for designing, analyzing, and interpreting diffusion MR experiments. Diffusion imaging provides a unique window on human brain anatomy. This non-invasive technique continues to grow in popularity as a way to study brain pathways that could never before be investigated in vivo. This book covers the fundamental theory of diffusion imaging, discusses its most promising applications to basic and clinical neuroscience, and introduces cutting-edge methodological developments that will shape the field in coming years. Written by leading experts in the field, it places the exciting new results emerging from diffusion imaging in the context of classical anatomical techniques to show where diffusion studies might offer unique insights and where potential limitations lie. Fully revised and updated edition of the first comprehensive reference on a powerful technique in brain imaging Covers all aspects of a diffusion MRI study from acquisition through analysis to interpretation, and from fundamental theory to cutting-edge developments New chapters covering connectomics, advanced diffusion acquisition, artifact removal, and applications to the neonatal brain Provides practical advice on running an experiment Includes discussion of applications in psychiatry, neurology, neurosurgery, and basic neuroscience Full color throughout

Diffusion MRI

Professor Derek Jones, a world authority on diffusion MRI, has assembled most of the world's leading scientists and clinicians developing and applying diffusion MRI to produce an authorship list that reads like a "Who's Who" of the field and an essential resource for those working with diffusion MRI. Destined to be a modern classic, this definitive and richly illustrated work covers all aspects of diffusion MRI from basic theory to clinical application. Oxford Clinical Neuroscience is a comprehensive, cross-searchable collection of resources offering quick and easy access to eleven of Oxford University Press's prestigious neuroscience texts. Joining Oxford Medicine Online these resources offer students, specialists and clinical researchers the best quality content in an easy-to-access format.

Diffusion Tensor Imaging

This book provides an overview of the practical aspects of diffusion tensor imaging (DTI), from understanding the basis of the technique through selection of the right protocols, trouble-shooting data quality, and analyzing DTI data optimally. DTI is a non-invasive magnetic resonance imaging (MRI) technique for visualizing and quantifying tissue microstructure based on diffusion. The book discusses the theoretical background underlying DTI and advanced techniques based on higher-order models and multi-shell diffusion imaging. It covers the practical implementation of DTI; derivation of information from DTI data; and a range of clinical applications, including neurosurgical planning and the assessment of brain tumors. Its practical utility is enhanced by decision schemes and a fully annotated DTI brain atlas, including color fractional anisotropy maps and 3D tractography reconstructions of major white matter fiber bundles. Featuring contributions from leading specialists in the field of DTI, *Diffusion Tensor Imaging: A Practical Handbook* is a valuable resource for radiologists, neuroradiologists, MRI technicians and clinicians.

Diffusion MRI Outside the Brain

Recent advances in MR technology permit the application of diffusion MRI outside of the brain. In this book, the authors present cases drawn from daily clinical practice to illustrate the role of diffusion sequences, along with other morphological and functional MRI information, in the work-up of a variety of frequently encountered oncological and non-oncological diseases. Breast, musculoskeletal, whole-body, and other applications are covered in detail, with careful explanation of the pros and cons of diffusion MRI in each circumstance. Quantification and post-processing are discussed, and advice is provided on how to acquire state of the art images, and avoid artifacts, when using 1.5- and 3-T magnets. Applications likely to emerge in the near future, such as for screening, are also reviewed. The practical approach adopted by the authors, combined with the wealth of high-quality illustrations, ensure that this book will be of great value to practitioners.

Diffusion-Weighted MR Imaging of the Brain

Few advances in MR imaging have had the impact degenerative neurologic disorders, white matter diseases, toxic/metabolic disorders, and tumors. As one evaluation of brain. From the time of the early descriptions by LeBihan and colleagues of the ability to image and measure the micromovement of water molecules in the brain to the present time, diffusion-weighted imaging has had a major impact in knowledge of what represents a normal adult brain the evaluation of multiple disease processes, primary and a normal developing brain along with an expanding role in ischemia, but also in other conditions of the brain. In most medical centers diffusion imaging is a valuable book. It is noteworthy that the authors have no longer considered a sequence to be used in special circumstances, but rather it is employed as part drawing on pathologic correlations in a number of routine MR imaging of the brain. Because the in- areas.

Diffusion-Weighted MR Imaging

It is a great privilege to introduce this book devoted to the current and future roles in research and clinical practice of another exciting new development in MRI: Diffusion-weighted MR imaging. This new, quick and non-invasive technique, which requires no contrast media or ionizing radiation, offers great potential for the detection and characterization of disease in the body as well as for the assessment of tumour response to therapy. Indeed, whereas DW-MRI is already firmly established for the study of the brain, progress in MR technology has only recently enabled its successful application in the body. Although the main focus of this book is on the role of DW-MRI in patients with malignant tumours, non-oncological emerging applications in other conditions are also discussed. The editors of this volume, Dr. D. M. Koh and Prof. H. Thoeny, are internationally well known for their pioneering work in the field and their original contributions to the literature on DW-MRI of the body. I am very much indebted to them for the enthusiasm and engagement with which they prepared and edited this splendid volume in a record short time for our series Medical Radiology – Diagnostic section.

Extra-Cranial Applications of Diffusion-Weighted MRI

Continuous improvement in MRI technology in recent years has led to the application of diffusion-weighted MR imaging in organ systems outside the brain. Extra-Cranial Applications of Diffusion-Weighted MRI provides an extensive review of current and future applications of this imaging modality by world-renowned experts. Organized by organ system, each chapter is highly illustrated, offering a balance of protocols, illustrations and principles of image interpretation. An initial chapter provides an overview of relevant physics and other technical details, followed by detailed chapters on all major body systems including liver, kidney, prostate, breast and spine. A final chapter discusses assessment of therapy response. Written and edited by leading DW-MRI experts worldwide, Extra-Cranial Applications of Diffusion-Weighted MRI is an

invaluable resource for radiology trainees, practising radiologists and for researchers in a wide variety of disciplines.

Advanced Diffusion Encoding Methods in MRI

The medical MRI community is by far the largest user of diffusion NMR techniques and this book captures the current surge of methods and provides a primary source to aid adoption in this field. There is a trend to adapting the more advanced diffusion encoding sequences developed by NMR researchers within the fields of porous media, chemical engineering, and colloid science to medical research. Recently published papers indicate great potential for improved diagnosis of the numerous pathological conditions associated with changes of tissue microstructure that are invisible to conventional diffusion MRI. This book disseminates these recent developments to the wider community of MRI researchers and clinicians. The chapters cover the theoretical basis, hardware and pulse sequences, data analysis and validation, and recent applications aimed at promoting further growth in the field. This is a fast moving field and chapters are written by key MRI scientists that have contributed to the successful translation of the advanced diffusion NMR methods to the context of medical MRI, from global locations.

Introduction to Diffusion Tensor Imaging

The concepts behind diffusion tensor imaging (DTI) are commonly difficult to grasp, even for magnetic resonance physicists. To make matters worse, a many more complex higher-order methods have been proposed over the last few years to overcome the now well-known deficiencies of DTI. In *Introduction to Diffusion Tensor Imaging: And Higher Order Models*, these concepts are explained through extensive use of illustrations rather than equations to help readers gain a more intuitive understanding of the inner workings of these techniques. Emphasis is placed on the interpretation of DTI images and tractography results, the design of experiments, and the types of application studies that can be undertaken. Diffusion MRI is a very active field of research, and theories and techniques are constantly evolving. To make sense of this constantly shifting landscape, there is a need for a textbook that explains the concepts behind how these techniques work in a way that is easy and intuitive to understand—*Introduction to Diffusion Tensor Imaging* fills this gap. Extensive use of illustrations to explain the concepts of diffusion tensor imaging and related methods Easy to understand, even without a background in physics Includes sections on image interpretation, experimental design, and applications Up-to-date information on more recent higher-order models, which are increasingly being used for clinical applications

Diffusion-Weighted MR Imaging of the Brain, Head and Neck, and Spine

This richly illustrated book, now in an updated and extended third edition, systematically covers the use of diffusion-weighted (DW) MR imaging in all major areas of neuroradiology, including imaging of the head and neck and the spine as well as the brain. The authors guide the reader from the basic principles of DW imaging through to the use of cutting-edge diffusion sequences such as diffusion tensor (DTI) and kurtosis (DKI), fiber tractography, high b value, intravoxel incoherent motion (IVIM), neurite orientation dispersion and density imaging (NODDI), and oscillating gradient spin echo (OGSE). Pathology, pathophysiology, and patient management and treatment are all thoroughly discussed. Since the early descriptions by LeBihan and colleagues of the ability to image and measure the micromovement of water molecules in the brain, diffusion imaging and its derivatives have contributed ever more significantly to the evaluation of multiple disease processes. In comprehensively describing the state of the art in the field, this book will be of high value not only for those who deal routinely with neuro-MR imaging but also for readers who wish to establish a sound basis for understanding diffusion images in the hope of extending these principles into more exotic areas of neuroimaging.

Diffusion Weighted and Diffusion Tensor Imaging

Diffusion-weighted imaging (DWI) is an integral part of routine neuroimaging, used nearly universally in brain MRIs, and more recently for the spine, spinal cord, and head and neck. DWI provides clinically relevant information on conditions including stroke, infection, and neoplasms. Diffusion tensor imaging (DTI) is a powerful, newer technique with the potential for multiple protocols, including the diagnosis of mild traumatic brain injury and psychiatric disorders. Written by leading authorities in neuroradiology and radiology, *Diffusion Weighted and Diffusion Tensor Imaging: A Clinical Guide* provides key points and summaries on the concepts and applications required for proper implementation and interpretation of DWI and DTI. Key Features: More than 600 high-quality illustrations Protocols and applications from early childhood to older adulthood Methods to differentiate normal versus pathological states Brain edema pathophysiology and use of DWI to distinguish between cytotoxic and vasogenic edema Utilization of DWI and DTI to diagnose trauma, white matter disease, tumors, cerebrovascular disease, and head, neck, and spine disorders This concise handbook is an invaluable resource for neuroradiologists and radiologists, as well as fellows and residents in these disciplines. With the expanding use of these procedures, neuroscientists, neurologists, neurosurgeons, and psychiatrists will also find it indispensable.

Advanced analysis of diffusion MRI data

Diffusion magnetic resonance imaging (diffusion MRI) is a non-invasive imaging modality which can measure diffusion of water molecules, by making the MRI acquisition sensitive to diffusion. Diffusion MRI provides unique possibilities to study structural connectivity of the human brain, e.g. how the white matter connects different parts of the brain. Diffusion MRI enables a range of tools that permit qualitative and quantitative assessments of many neurological disorders, such as stroke and Parkinson. This thesis introduces novel methods for diffusion MRI data analysis. Prior to estimating a diffusion model in each location (voxel) of the brain, the diffusion data needs to be preprocessed to correct for geometric distortions and head motion. A deep learning approach to synthesize diffusion scalar maps from a T1-weighted MR image is proposed, and it is shown that the distortion-free synthesized images can be used for distortion correction. An evaluation, involving both simulated data and real data, of six methods for susceptibility distortion correction is also presented in this thesis. A common problem in diffusion MRI is to estimate the uncertainty of a diffusion model. An empirical evaluation of tractography, a technique that permits reconstruction of white matter pathways in the human brain, is presented in this thesis. The evaluation is based on analyzing 32 diffusion datasets from a single healthy subject, to study how reliable tractography is. In most cases only a single dataset is available for each subject. This thesis presents methods based on frequentistic (bootstrap) as well as Bayesian inference, which can provide uncertainty estimates when only a single dataset is available. These uncertainty measures can then, for example, be used in a group analysis to downweight subjects with a higher uncertainty.

DIFFUSION MRI OF THE BREAST, E-Book

Diffusion weighted imaging (DWI) is a key emerging imaging modality for the management of patients with possible breast lesions, and *Diffusion MRI of the Breast* is the first book to focus on all aspects of DWI in today's practice. It covers the knowledge necessary to undertake clinical breast DWI, with a thorough review of how DWI is currently used as a breast imaging modality and how breast lesions appear on DWI. Expert clinicians and physicists from around the world share their knowledge and expertise on everything from technical requirements and image analysis to clinical applications of DWI (diagnosis, prognosis, treatment monitoring) with case examples, and upcoming developments in the field (radiomics, AI). Offers an in-depth discussion of DWI's clinical applications in breast imaging, including the position of DWI with respect to other modalities, the use of DWI in the diagnosis of suspicious lesions with a multiparametric protocol, the use of DWI as an imaging biomarker of prognosis and response prediction, the potential role of DWI for unenhanced breast MR screening, and more. Provides a basic introduction to DWI before discussing a practical approach to clinical interpretation and quality assurance issues. Covers specific challenges and

advanced techniques (IVIM, non-Gaussian diffusion, DTI, and other novel techniques), radiomics and artificial intelligence, and different vendor approaches in breast DWI packages. Features more than 500 high-quality images throughout. Explains how DWI could be specifically used to provide information on prognosis and prediction factors. Evaluates the current status of DWI, its potential for the management of breast cancer patients, and possible future developments in the field.

Diffusion MRI

Since its initial development in the mid-1980's, and wide accessibility to perform diffusion MRI on all MRI scanners, the use of diffusion MRI has exploded. Nearly every MRI centre carries out diffusion MRI of some kind. Obtaining good quality diffusion MRI and making sound and robust inferences from the data is not trivial, however, and involves a long chain of events from ensuring that the hardware is performing optimally, the pulse sequence is carefully designed, the acquisition is optimal, the data quality is maximized while artifacts are minimized, the appropriate post-processing is used.

Diffusion Weighted Imaging of the Genitourinary System

This book discusses diffusion weighted imaging (DWI) and its evolving clinical role. DWI has frequently been used in the abdomen and pelvis but is now increasingly being used in other clinical applications, especially for the diagnostic workup of oncologic patients. Standardization and clinical validation of quantitative DWI related biomarkers is still ongoing, although efforts have been undertaken, especially in the prostate, to provide standardized imaging guidelines for different clinical indications. The technical aspects and clinical applications of DWI presented focus on the respective anatomical region and its pathologies. The book is unique in providing tables of technical details (imaging protocols, artifacts, optimization techniques) for each chapter, making this complex area as simple and practical as possible. The book is intended for radiologists interested in urogenital radiology and also for radiology residents.

Introduction to Diffusion Tensor Imaging

The concept of Diffusion Tensor Imaging (DTI) is often difficult to grasp, even for Magnetic Resonance physicists. Introduction to Diffusion Tensor Imaging uses extensive illustrations (not equations) to help readers to understand how DTI works. Emphasis is placed on the interpretation of DTI images, the design of DTI experiments, and the forms of application studies. The theory of DTI is constantly evolving and so there is a need for a textbook that explains how the technique works in a way that is easy to understand - Introduction to Diffusion Tensor Imaging fills this gap. * Uses extensive illustrations to explain the concept of Diffusion Tensor Imaging * Easy to understand, even without a background in physics * Includes sections on image interpretation, experimental design and applications

Diffusion MRI

Provides the basic principles and interpretation of diffusion-weighted MR imaging. Discusses the pitfalls and artifacts of DW imaging, basics of diffusion measurements by MRI, brain edema, infarction, intracranial hemorrhage, epilepsy, demyelinating and degenerative disease, and more. Abundant illustrations.

Diffusion-weighted MR Imaging of the Brain

Diffusion Tensor Imaging (DTI) is a variation of diffusion-weighted imaging. Particularly in the neurosciences, this technique has gained tremendous momentum in the past decade, both from a technical point of view as well as in its applications. DTI is mainly used in neurological diagnosis and psychiatric and neurologic research, e.g. in order to locate brain tumors and depict their invasivity. DTI offers a unique in-vivo insight into the three-dimensional structure of the human central nervous system. While easy

interpretation and evaluation is often hampered by the complexity of both the technique and neuroanatomy, this atlas helps you recognize every one of the important structures rapidly and unambiguously. In the introduction, this atlas provides a concise outline of the evolution of diffusion imaging and describes its potential applications. In the core part of the atlas, the neuroanatomically important structures are clearly labeled both on DTI-derived color maps and conventional MRI. Complex fiber architecture is illustrated schematically and described concisely in textboxes directly on the relevant page. In the final part of the atlas, a straightforward, step-by-step approach for the three-dimensional reconstruction of the most prominent fiber structures is given, and potential pitfalls are indicated. The atlas aims at neuroscientists, neuroanatomists, neurologists, psychiatrists, clinical psychologists, physicists, and computer scientists. For advanced users, the atlas may serve as a reference work, while students and scientists are thoroughly introduced in DTI.

Diffusion Tensor Imaging

This book explains how diffusion weighted imaging has been incorporated in routine MRI examinations of the abdomen and pelvis: though its clinical role is still evolving, it is already considered an important tool for the assessment of rectal cancer treatment response, as was confirmed in recent ESGAR consensus statements. The standardization and clinical validation of quantitative DWI related biomarkers are still in progress, although certain efforts have been undertaken to establish imaging guidelines for different clinical indications/body parts. The book reviews the technical aspects and clinical applications of DWI in imaging of the GI tract, and provides specific technical details (imaging protocols, artefacts, optimization techniques) for each GI tract division. This volume is mainly intended for radiologists who are interested in abdominal radiology, as well as radiology residents. Given that magnetic resonance physics is complex and can be cumbersome to learn, the authors have made it as simple and practical as possible.

Diffusion Weighted Imaging of the Gastrointestinal Tract

Intravoxel incoherent motion (IVIM) refers to translational movements which within a given voxel and during the measurement time present a distribution of speeds in orientation and/or amplitude. The concept was introduced in 1986 together with the foundation of diffusion MRI because it had been realized that flow of blood in capillaries (perfusion) would mimic a diffusion process and impact diffusion MRI measurements. IVIM-based perfusion MRI, which does not require injection of any tracer or contrast agent, has been first investigated in the brain, but is now experiencing a remarkable revival for applications throughout the body, especially for oncologic applications, from diagnosis to treatment monitoring. This book addresses a number of highly topical aspects of the field from leading authorities, introducing the concepts behind IVIM MRI, outlining related methodological issues, and summarizing its current usage and potential for clinical applications. It also presents future research directions, both in terms of methodological development and clinical application fields, extending to new, non-perfusion applications of IVIM MRI, such as virtual MR elastography.

Intravoxel Incoherent Motion (IVIM) MRI

This volume gathers papers presented at the Workshop on Computational Diffusion MRI (CDMRI'18), which was held under the auspices of the International Conference on Medical Image Computing and Computer Assisted Intervention in Granada, Spain on September 20, 2018. It presents the latest developments in the highly active and rapidly growing field of diffusion MRI. The reader will find papers on a broad range of topics, from the mathematical foundations of the diffusion process and signal generation, to new computational methods and estimation techniques for the in-vivo recovery of microstructural and connectivity features, as well as harmonisation and frontline applications in research and clinical practice. The respective papers constitute invited works from high-profile researchers with a specific focus on three topics that are now gaining momentum within the diffusion MRI community: i) machine learning for diffusion MRI; ii) diffusion MRI outside the brain (e.g. in the placenta); and iii) diffusion MRI for multimodal imaging. The book shares new perspectives on the latest research challenges for those currently

working in the field, but also offers a valuable starting point for anyone interested in learning computational techniques in diffusion MRI. It includes rigorous mathematical derivations, a wealth of full-colour visualisations, and clinically relevant results. As such, it will be of interest to researchers and practitioners in the fields of computer science, MRI physics and applied mathematics alike.

Computational Diffusion MRI

Diffusion magnetic resonance imaging (MRI) is an MRI method that provides information about random microscopic motion of water molecules in biological tissues. In addition to offering a higher sensitivity for the diagnosis of white matter diseases such as stroke and multiple sclerosis, and producing connectivity maps of the brain, it is a promising prognostic tool in the assessment and treatment response monitoring of cancer in the body. While high in-plane resolution is desirable for all diffusion MRI applications, it is particularly essential for imaging of small structures. Unfortunately, the performance of diffusion MRI techniques is often hindered by a variety of factors including susceptibility variations, field inhomogeneities and bulk physiologic motion. This thesis presents a reduced field-of-view (FOV) single-shot echo-planar imaging (ss-EPI) method to address these problems and enable high-resolution diffusion MRI of targeted regions. The proposed method utilizes a two-dimensional (2D) echo-planar radio-frequency (RF) excitation pulse to achieve a sharp reduced-FOV profile, while still allowing contiguous multi-slice imaging and suppressing the fat signal. Extensive clinical evaluation of the technique demonstrated that sub-mm diffusion-weighted imaging (DWI) on human spinal cords is feasible with minimal artifacts. High-resolution fiber tractography of the spinal cord successfully visualized the connectivity between the cord and the medulla oblongata, delineating internal structures such as gray/white matter. In vivo DWI of the larynx, breast and prostate validated the effectiveness of this technique in providing detailed depiction of the morphology outside the central nervous system. When the exponential diffusion attenuation is combined with high spatial resolution, DWI may suffer from poor signal-to-noise ratio (SNR). The last part of this thesis presents an optimization strategy for the DWI parameters as a function of the imaging SNR. Specifically, the optimum b-value is shown to be a monotonically increasing function of the imaging SNR, with a convergence asymptote identical to the previously proposed values in literature. The effects of T2 relaxation are also incorporated for a more accurate optimization. In vitro and in vivo experiments demonstrated reduced error in ADC estimations and improved SNR in the diffusion-weighted images with the proposed technique.

High-resolution Diffusion MRI of Targeted Regions

This volume presents the latest developments in the highly active and rapidly growing field of diffusion MRI. The reader will find numerous contributions covering a broad range of topics, from the mathematical foundations of the diffusion process and signal generation, to new computational methods and estimation techniques for the in-vivo recovery of microstructural and connectivity features, as well as frontline applications in neuroscience research and clinical practice. These proceedings contain the papers presented at the 2017 MICCAI Workshop on Computational Diffusion MRI (CDMRI'17) held in Québec, Canada on September 10, 2017, sharing new perspectives on the most recent research challenges for those currently working in the field, but also offering a valuable starting point for anyone interested in learning computational techniques in diffusion MRI. This book includes rigorous mathematical derivations, a large number of rich, full-colour visualisations and clinically relevant results. As such, it will be of interest to researchers and practitioners in the fields of computer science, MRI physics and applied mathematics.

Computational Diffusion MRI

This book constitutes the proceedings of the International Workshop on Computational Diffusion MRI, CDMRI 2021, which was held on October 1, 2021, in conjunction with MICCAI 2021. The conference was planned to take place in Strasbourg, France, but was held virtually due to the COVID-19 pandemic. The 13 full papers included were carefully reviewed and selected for inclusion in the book. The proceedings also contain a paper about the design and scope of the MICCAI Diffusion-Simulated Connectivity Challenge

(DiSCo) which was held at CDMRI 2021. The papers were organized in topical sections as follows: acquisition; microstructure modelling; tractography and connectivity; applications and visualization; DiSCo challenge – invited contribution.

Computational Diffusion MRI

This volume offers a valuable starting point for anyone interested in learning computational diffusion MRI and mathematical methods for brain connectivity, while also sharing new perspectives and insights on the latest research challenges for those currently working in the field. Over the last decade, interest in diffusion MRI has virtually exploded. The technique provides unique insights into the microstructure of living tissue and enables in-vivo connectivity mapping of the brain. Computational techniques are key to the continued success and development of diffusion MRI and to its widespread transfer into the clinic, while new processing methods are essential to addressing issues at each stage of the diffusion MRI pipeline: acquisition, reconstruction, modeling and model fitting, image processing, fiber tracking, connectivity mapping, visualization, group studies and inference. These papers from the 2016 MICCAI Workshop “Computational Diffusion MRI” – which was intended to provide a snapshot of the latest developments within the highly active and growing field of diffusion MR – cover a wide range of topics, from fundamental theoretical work on mathematical modeling, to the development and evaluation of robust algorithms and applications in neuroscientific studies and clinical practice. The contributions include rigorous mathematical derivations, a wealth of rich, full-color visualizations, and biologically or clinically relevant results. As such, they will be of interest to researchers and practitioners in the fields of computer science, MR physics, and applied mathematics.

Computational Diffusion MRI

This issue of MRI Clinics focuses on Advances in Diffusion-weighted Imaging and is edited by Dr. Kei Yamada. Articles will include: Technical Basics of Diffusion-weighted Imaging; Neurofluid as Assessed by Diffusion-weighted Imaging; Diffusion-weighted Imaging is the Key to Diagnoses; Diffusion-weighted Imaging of the Spinal Cord; Intracranial Abnormalities with Diffusion Restriction; Brain Anatomy by Diffusion-weighted Imaging; Measuring Perfusion: Intravoxel Incoherent Motion; Temperature Measurement by Diffusion-weighted Imaging; Diffusion-weighted Imaging at Ultra-high Field MRI; Diffusion-weighted Imaging for Radiomics; Diffusion Weighted Imaging for Infants; Diffusion-weighted Imaging of the Head and Neck (Including Temporal Bone); DTI, DKI and Q-space Imaging; and more!

Diffusion MRI

These Proceedings of the 2015 MICCAI Workshop “Computational Diffusion MRI” offer a snapshot of the current state of the art on a broad range of topics within the highly active and growing field of diffusion MRI. The topics vary from fundamental theoretical work on mathematical modeling, to the development and evaluation of robust algorithms, new computational methods applied to diffusion magnetic resonance imaging data, and applications in neuroscientific studies and clinical practice. Over the last decade interest in diffusion MRI has exploded. The technique provides unique insights into the microstructure of living tissue and enables in-vivo connectivity mapping of the brain. Computational techniques are key to the continued success and development of diffusion MRI and to its widespread transfer into clinical practice. New processing methods are essential for addressing issues at each stage of the diffusion MRI pipeline: acquisition, reconstruction, modeling and model fitting, image processing, fiber tracking, connectivity mapping, visualization, group studies and inference. This volume, which includes both careful mathematical derivations and a wealth of rich, full-color visualizations and biologically or clinically relevant results, offers a valuable starting point for anyone interested in learning about computational diffusion MRI and mathematical methods for mapping brain connectivity, as well as new perspectives and insights on current research challenges for those currently working in the field. It will be of interest to researchers and practitioners in the fields of computer science, MR physics, and applied mathematics.

MRI Clinics of North America, an Issue of Magnetic Resonance Imaging Clinics of North America, Volume 29-2

This book contains papers presented at the 2014 MICCAI Workshop on Computational Diffusion MRI, CDMRI'14. Detailing new computational methods applied to diffusion magnetic resonance imaging data, it offers readers a snapshot of the current state of the art and covers a wide range of topics from fundamental theoretical work on mathematical modeling to the development and evaluation of robust algorithms and applications in neuroscientific studies and clinical practice. Inside, readers will find information on brain network analysis, mathematical modeling for clinical applications, tissue microstructure imaging, super-resolution methods, signal reconstruction, visualization, and more. Contributions include both careful mathematical derivations and a large number of rich full-color visualizations. Computational techniques are key to the continued success and development of diffusion MRI and to its widespread transfer into the clinic. This volume will offer a valuable starting point for anyone interested in learning computational diffusion MRI. It also offers new perspectives and insights on current research challenges for those currently in the field. The book will be of interest to researchers and practitioners in computer science, MR physics, and applied mathematics.

Computational Diffusion MRI

This book constitutes the proceedings of the International Workshop on Computational Diffusion MRI, CDMRI 2022, which was held 22 September 2022, in conjunction with MICCAI 2022. The 12 full papers included were carefully reviewed and selected for inclusion in the book. The papers were organized in topical sections as follows: Data processing, Signal representations, Tractography and WM pathways.

Computational Diffusion MRI

Diffusion-weighted MR imaging is widely accepted as a means to identify stroke, thus enabling rapid and effective treatment. Over the past four years, these expert authors have presented over 30 exhibits and scientific reports on diffusion-weighted imaging at the RSNA and the American Society of Neuroradiology (ASNR), and more than 10 of these presentations have been recognized by specific awards. Diffusion-Weighted MR Imaging of the Brain's chapters range from basic principles to interpretation of diffusion-weighted MR imaging and specific disease. This is a valuable reference for radiologists, neurologists, neurosurgeons as well as residents, fellows, radiology technologists.

Computational Diffusion MRI

This book focuses on the use of artificial intelligence to address a specific problem in the brain – the orientation distribution function. It discusses three aspects: (i) Preparing, enhancing and evaluating one of the cuckoo search algorithms (CSA); (ii) Describing the problem: Diffusion-weighted magnetic resonance imaging (DW-MRI) is used for non-invasive investigations of anatomical connectivity in the human brain, while Q-ball imaging (QBI) is a diffusion MRI reconstruction technique based on the orientation distribution function (ODF), which detects the dominant fiber orientations; however, ODF lacks local estimation accuracy along the path. (iii) Evaluating the performance of the CSA versions in solving the ODF problem using synthetic and real-world data. This book appeals to both postgraduates and researchers who are interested in the fields of medicine and computer science.

Novel Approach to Three-dimensional Diffusion MRI

Quantitative Magnetic Resonance Imaging is a 'go-to' reference for methods and applications of quantitative magnetic resonance imaging, with specific sections on Relaxometry, Perfusion, and Diffusion. Each section will start with an explanation of the basic techniques for mapping the tissue property in question, including a

description of the challenges that arise when using these basic approaches. For properties which can be measured in multiple ways, each of these basic methods will be described in separate chapters. Following the basics, a chapter in each section presents more advanced and recently proposed techniques for quantitative tissue property mapping, with a concluding chapter on clinical applications. The reader will learn: The basic physics behind tissue property mapping How to implement basic pulse sequences for the quantitative measurement of tissue properties The strengths and limitations to the basic and more rapid methods for mapping the magnetic relaxation properties T1, T2, and T2* The pros and cons for different approaches to mapping perfusion The methods of Diffusion-weighted imaging and how this approach can be used to generate diffusion tensor maps and more complex representations of diffusion How flow, magneto-electric tissue property, fat fraction, exchange, elastography, and temperature mapping are performed How fast imaging approaches including parallel imaging, compressed sensing, and Magnetic Resonance Fingerprinting can be used to accelerate or improve tissue property mapping schemes How tissue property mapping is used clinically in different organs Structured to cater for MRI researchers and graduate students with a wide variety of backgrounds Explains basic methods for quantitatively measuring tissue properties with MRI - including T1, T2, perfusion, diffusion, fat and iron fraction, elastography, flow, susceptibility - enabling the implementation of pulse sequences to perform measurements Shows the limitations of the techniques and explains the challenges to the clinical adoption of these traditional methods, presenting the latest research in rapid quantitative imaging which has the possibility to tackle these challenges Each section contains a chapter explaining the basics of novel ideas for quantitative mapping, such as compressed sensing and Magnetic Resonance Fingerprinting-based approaches

Diffusion-Weighted MR Imaging of the Brain

Radiotherapy plays an increasingly important role in cancer treatment, and medical imaging plays an increasingly important role in radiotherapy. Magnetic resonance imaging (MRI) is poised to be a major component in the development towards more effective radiotherapy treatments with fewer side effects. This thesis attempts to contribute in realizing this potential. Radiotherapy planning requires simulation of radiation transport. The necessary physical properties are typically derived from CT images, but in some cases only MR images are available. In such a case, a crude but common approach is to approximate all tissue properties as equivalent to those of water. In this thesis we propose two methods to improve upon this approximation. The first uses a machine learning approach to automatically identify bone tissue in MR. The second, which we refer to as atlas-based regression, can be used to generate a realistic, patient-specific, pseudo-CT directly from anatomical MR images. Atlas-based regression uses deformable registration to estimate a pseudo-CT of a new patient based on a database of aligned MR and CT pairs. Cancerous tissue has a different structure from normal tissue. This affects molecular diffusion, which can be measured using MRI. The prototypical diffusion encoding sequence has recently been challenged with the introduction of more general gradient waveforms. One such example is diffusional variance decomposition (DIVIDE), which allows non-invasive mapping of parameters that reflect variable cell eccentricity and density in brain tumors. To take full advantage of such more general gradient waveforms it is, however, imperative to respect the constraints imposed by the hardware while at the same time maximizing the diffusion encoding strength. In this thesis we formulate this as a constrained optimization problem that is easily adaptable to various hardware constraints. We demonstrate that, by using the optimized gradient waveforms, it is technically feasible to perform whole-brain diffusional variance decomposition at clinical MRI systems with varying performance. The last part of the thesis is devoted to estimation of diffusion MRI models from measurements. We show that, by using a machine learning framework called Gaussian processes, it is possible to perform diffusion spectrum imaging using far fewer measurements than ordinarily required. This has the potential of making diffusion spectrum imaging feasible even though the acquisition time is limited. A key property of Gaussian processes, which is a probabilistic model, is that it comes with a rigorous way of reasoning about uncertainty. This is pursued further in the last paper, in which we propose a Bayesian reinterpretation of several of the most popular models for diffusion MRI. Thanks to the Bayesian interpretation it is possible to quantify the uncertainty in any property derived from these models. We expect this will be broadly useful, in particular in group analyses and in cases when the uncertainty is large.

Artificial Intelligence in Diffusion MRI

This richly illustrated book, now in an updated and extended third edition, systematically covers the use of diffusion-weighted (DW) MR imaging in all major areas of neuroradiology, including imaging of the head and neck and the spine as well as the brain. The authors guide the reader from the basic principles of DW imaging through to the use of cutting-edge diffusion sequences such as diffusion tensor (DTI) and kurtosis (DKI), fiber tractography, high b value, intravoxel incoherent motion (IVIM), neurite orientation dispersion and density imaging (NODDI), and oscillating gradient spin echo (OGSE). Pathology, pathophysiology, and patient management and treatment are all thoroughly discussed. Since the early descriptions by LeBihan and colleagues of the ability to image and measure the micromovement of water molecules in the brain, diffusion imaging and its derivatives have contributed ever more significantly to the evaluation of multiple disease processes. In comprehensively describing the state of the art in the field, this book will be of high value not only for those who deal routinely with neuro-MR imaging but also for readers who wish to establish a sound basis for understanding diffusion images in the hope of extending these principles into more exotic areas of neuroimaging.

Quantitative Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) and spectroscopy (MRS) techniques have opened new doors for examining biological tissues *in vivo*. By combining sensitization to diffusion using magnetic field gradients with a variety of imaging and localization schemes, diffusion-weighted MRI and diffusion-weighted MRS allow investigating translational diffusion of endogenous molecules, such as water or metabolites, in biological tissues, most commonly the brain but also other organs such as the prostate. The typical voxel resolution of MRI or MRS is in the millimeter to centimeter range, much lower than the cellular scale. However, as molecules are typically diffusing over just a few μm during the duration of the measurement (the “diffusion time”) and encounter numerous biological membranes at these scales, the average cellular microstructure has a critical influence on the measured diffusion signal. Hence, diffusion-weighted MRI and diffusion-weighted MRS are sensitive to tissue microstructure at a scale well below the nominal imaging resolution. However, the connection between diffusion properties and tissue microstructure remains indirect, so any attempt to quantify microstructure will rely on modeling. The goal of this Research Topic was to gather experts in various acquisition and modeling strategies and show how these approaches, despite their own strengths and weaknesses, can yield unique information about cellular microstructure, and sometimes complement each other.

Algorithms for magnetic resonance imaging in radiotherapy

This is a book about advanced neuroimaging techniques used for the diagnosis of a wide range of brain disorders.

Diffusion Weighted MR Imaging of the Brain, Head and Neck, and Spine

This volume contains the proceedings from two closely related workshops: Computational Diffusion MRI (CDMRI'13) and Mathematical Methods from Brain Connectivity (MMBC'13), held under the auspices of the 16th International Conference on Medical Image Computing and Computer Assisted Intervention, which took place in Nagoya, Japan, September 2013. Inside, readers will find contributions ranging from mathematical foundations and novel methods for the validation of inferring large-scale connectivity from neuroimaging data to the statistical analysis of the data, accelerated methods for data acquisition, and the most recent developments on mathematical diffusion modeling. This volume offers a valuable starting point for anyone interested in learning computational diffusion MRI and mathematical methods for brain connectivity as well as offers new perspectives and insights on current research challenges for those currently in the field. It will be of interest to researchers and practitioners in computer science, MR physics, and

applied mathematics.

Assessing Cellular Microstructure in Biological Tissues using In Vivo Diffusion-Weighted Magnetic Resonance

Clinical MR Neuroimaging