DIGITAL MOLECULAR MAGNETIC RESONANCE IMAGING
By Bamidele O. Awojoyogbe, Michael O. Dada

A.N. Mumuni[1,2]

[1] Department of Medical Imaging, University for Development Studies, Tamale, Ghana
[2] Director, Diagnostic Imaging Research Centre, University for Development Studies, Tamale, Ghana

I. BOOK DETAILS

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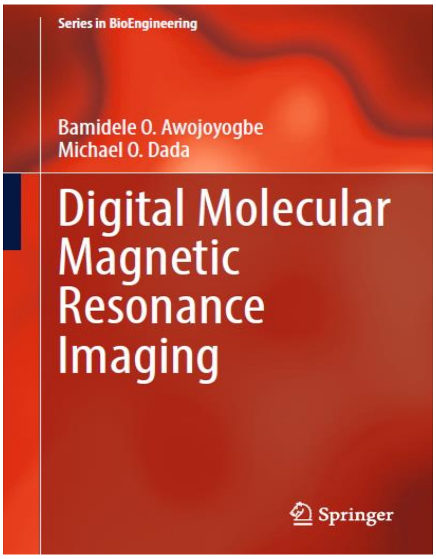

II. REVIEW

Digital Molecular Magnetic Resonance Imaging is an elaborately packaged reference manual for medical physicists, computer scientists, engineers, research scientists, and medical professionals at any level of their respective careers. The choice of topics covered in the content is also well-suited for undergraduate and postgraduate students of these respective fields.

Published as a Series in BioEngineering, the book has fifteen (15) chapters, each of which is independent of the other, presented sequentially to describe the theory of the primary source of signal for magnetic resonance imaging (MRI) and how the nuclear magnetic resonance (NMR) properties of various imaging samples can be manipulated at the molecular level to provide various signal characteristics in MRI for tissue characterization. With a common theme running through all the chapters of the book, each chapter has its own introduction describing the objective, theme and content presented, with in-text citations listed as references at the end of the chapter.

The main themes covered in the book include NMR and MRI theories, NMR signal and image processing techniques, artificial intelligence (AI) and machine learning techniques for digital healthcare, optimization of machine learning algorithms for image classification and diagnosis, application of physics-based knowledge and machine learning in studies of molecular dynamics and tissue characterization toward understanding of origins of disease, development and deployment of computerized platforms to perform various tasks in image processing, and democratization of MRI access through quantum computing. In summary, the book is absolutely an excellent guide for MRI data processing, analysis, classification and by extension development of advanced methods for imaging science applications. The subject matter is well articulated and presented in a comprehensive manner that will keep any MRI enthusiast glued to the text to the very last page.

The following contents in the book are worthy of mention to the prospective reader:

The opening chapter describes the fundamental theories of NMR, spin relaxation, and diffusion relating them to imaging features in MRI. By combining physics-based knowledge with neural networks, methods are suggested and implemented in step-by-step procedures for denoising, feature extraction, and segmentation of MR images. Imaging scientists interested in understanding the use of the image processing pipelines in FSL particularly for functional MRI studies will definitely want to read chapter 1 of this book.

As an important physiological parameter in MRI, the origins of temperature generation and distribution in the body are simulated using physics-informed neural network methods in chapters 2, 7 and 8. This provides the molecular basis for hyperthermia and its influence on quantum mechanical properties of tissue, as demonstrated by thermal diffusivity, conductivity and blood perfusion in the kidney and skin (presented in chapter 8). Biophysicists, mathematicians, and computer scientists will find these three chapters very useful and interesting to read.

Chapter 3 opens the door to a more fascinating mix of mathematics, physics, computing, medicine and imaging sciences. From chapter 4 onward, the reader will find more useful content about development and optimization of various image processing and classification algorithms based on a combined model of physics-based knowledge and artificial intelligence (AI). The authors demonstrate tact in laying excellent foundation for each chapter, highlighting the major research and clinical problem being investigated and solved intelligently (which will amaze the reader) using physics principles implemented through machine learning. Of particular interest is the extension of this combined model in chapter 11 where a scheme for molecular MR fingerprinting of disease to explain the origins of pathology is presented. The challenge of access to big data for model training and simulation is carefully surmounted by the authors by depending on various image data repositories, links to which have been provided in all cases. Thus, the book does not only provide relevant content to teach, inform and guide, it also provides very useful datasets to research scientists in the field of machine learning.

In chapters 5 and 6, the focus turns to telemedicine and personalized healthcare. Using relaxometry data, the utility of machine learning is demonstrated in the design of a web-based service android application as a first-line decision support system for diagnosis of cardiovascular and Alzheimer's diseases, respectively.

While chapter 9 examines the selection of a high-performing deep learning model for accurate brain tumor classification using brain MR images, chapter 13 implements a refined version of the model tailored for web-based application for brain MRI processing and tumor classification. The work presented provides a ready-to-use platform for clinicians to use as first-line diagnostic tool in brain cancer examination and staging by uploading brain MR images of patients to the platform.

Medical image processing and analysis software generally display images in 2-dimensional views, restricting the flexibility of the user to view images from varied angles at their convenience. Normally, 3-dimensional displays offer more flexibility for image analysis, surgical planning, training, and telemedicine applications. An established framework based on neural radiance fields (NeRFs) for 3-dimensional image reconstruction and rendering is presented succinctly in chapter 10. As a general concluding remark in chapter 14, the potential scope of applications and power of NeRFs in coordinate-based 3-dimensional display of images for enhanced rendering effects are discussed.

While implementing quantum artificial intelligence to demonstrate magnetic resonance imaging at low and high fields in chapter 12, the authors advocate for capacity building and establishment of research laboratories to implement quantum computing in chapter 15, the last chapter. Based on research experiences so far, quantum computing solutions can be leveraged to deploy MRI applications in resource-limited settings as a promising step toward democratization of MRI access. Low-field MRI systems are relatively cheaper to procure and maintain, and are largely built to satisfy the needs of resource-constrained settings. Such MRI systems however have lesser imaging capabilities compared to the commonly installed clinical systems at relatively high field strengths. In practice, the performance of low-field MRI systems can be upgraded through digital quantum computing to solve most of the MRI accessibility issues in resource-limited settings. Practical steps toward achieving this feat are outlined in this last chapter of the book.

These last few concluding paragraphs from the book sum up all it has to offer its prospective readership:

In predictive analytics and deep learning, quantum computing offers the potential to process vast datasets far more efficiently. This efficiency could significantly advance AI's ability to predict outcomes from large and complex data sets, such as personalized medicine.

In summary, the proposed laboratory for research and capacity building in ***Digital Molecular Magnetic Resonance Imaging*** *will be a digitally generated magnetic resonance signal using the fundamental Bloch NMR flow model equation, Physics-informed Neural Networks (PNN) and Artificial Intelligence to design and deploy magnetic resonance systems with the capacity to work in a digital manner with features of low cost, high performance and accuracy.*

As we peer into this quantum horizon in MRI, a new initiative involving International Society for Magnetic Resonance in Medicine (ISMRM), World Molecular Imaging Society (WMIS), top related research institutes and companies should be motivated to establish Quantum MRI computing laboratories in strategic regions to democratize access to quantum computing that may be able to tackle some of the most pressing global challenges in modern medicine bridging physics and digital health.

In conclusion, the book is a good source of information to readers from a wide range of disciplines beyond physics in medicine focusing on the topic of MRI. It is highly recommended for any reader desiring to explore varied methods of data analysis leveraging automated or computerized models at high speed and accuracy in results.

III. REFERENCE

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