Advances in Quantitative MRI: Acquisition, Estimation, and Applications

by

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ABSTRACT

Advances in Quantitative MRI:
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We show that it is possible to get approximate solutions to analytically intractable equations using iterative methods. Thus we show that the author could pass an undergraduate class in numerical analysis. In addition, a unique extension to Brent's method is proposed that results in slight improvements in convergence.

CHAPTER 1

Introduction

{c,intro}

Magnetic resonance imaging (MRI) is a non-invasive tool that has earned widespread clinical adoption due (among other factors) to its potential for excellent soft tissue contrast, its avoidance of ionizing radiation, and its flexibility to characterize many physical phenomena. Despite its numerous advantages, MRI requires highly specialized hardware, ongoing liquid-helium cooling of its superconducting main magnet, and comparably long scan times. For these reasons, MRI is (somewhat inherently) expensive relative to other medical imaging modalities. Accordingly, one broad initiative recently advocated by the MR community is to increase the *value* of MRI examinations.

Two reasonable measures of an acquisition's value are its *sensitivity* to a given disorder's onset and progression and its *specificity* in distinguishing it from others. The field of *pathology* seeks to ascribe physical processes to disorders of interest with high sensitivity and specificity. The field of *quantitative MRI* (QMRI) seeks to build measurable MRI biomarkers that describe such physical processes and thereby provide indirect information about underlying conditions.

QMRI poses several challenges beyond those of MR image reconstruction, and thus remains yet to be widely adopted clinically. For example, latent parameter "maps" that describe relevant physical processes are often related to the received MR signal through complicated, highly nonlinear relationships. Furthermore, practical MR pulse sequences produce signals that are usually functions of not only desired but also nuisance parameters. Scan repetition is often necessary for accurate estimation of multiple desired and nuisance parameters, which can increase scan times. Mitigating these challenges (and likely others) is essential to furthering widespread clinical adoption of QMRI techniques.

1.1 Thesis Overview

{s,intro,over}

CHAPTER 2

Background

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CHAPTER 3

MRI Parameter Estimation from Likelihood Models

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CHAPTER 4

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{c,mwf}

CHAPTER 7

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CHAPTER 8

Future Work

{c,future}

APPENDIX A

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{a,cc-multi}

APPENDIX B

DESS in the Presence of Diffusion

{a,dess-diff}

BIBLIOGRAPHY