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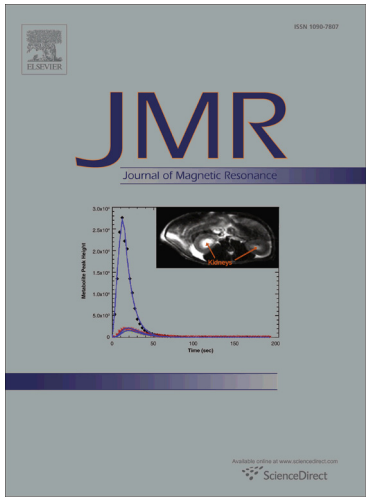

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ACCEPTED MANUSCRIPT

A framework for accurate determination of the T_2 distribution from multiple echo magnitude MRI images

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Abstract

Measurement of the T_2 distribution in tissues provides biologically relevant information about normal and abnormal microstructure and organization. Typically, the T_2 distribution is obtained by fitting the magnitude MR images acquired by a multi-echo MRI pulse sequence using an inverse Laplace transform (ILT) algorithm. It is well known that the ideal magnitude MR signal follows a Rician distribution. Unfortunately, studies attempting to establish the validity and efficacy of the ILT algorithm assume that these input signals are Gaussian distributed. Violation of the normality (or Gaussian) assumption introduces unexpected artifacts, including spurious cerebrospinal fluid (CSF)-like long T_2 components; bias of the true geometric mean T_2 values and in the relative fractions of various components; and blurring of nearby T_2 peaks in the T_2 distribution. Here we apply and extend our previously proposed magnitude signal transformation framework to map noisy Rician-distributed magnitude multi-echo MRI signals into Gaussian-distributed signals with high accuracy and precision. We then perform an ILT on the transformed data to obtain an accurate T_2 distribution. Additionally, we demonstrate, by simulations and experiments, that this approach corrects the aforementioned artifacts in magnitude multi-echo MR images over a large range of signal-to-noise ratios.

Keywords: T_2 distribution, MRI, multi-echo, magnitude, Rician, Gaussian, signal, probability integral transform.

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1. Introduction

NMR relaxation measurements have been widely applied to study molecular dynamics in porous media [1,2], polymers and gels [3–5], food sciences [6], material sciences [7], plant tissue [8], and animal and human tissue studies [9,10]. NMR relaxometry, combined with MR imaging, is a powerful tool for characterizing the detailed microstructure of animal and human tissue *ex vivo* and *in vivo*, revealing complex microstructure in the brain [11–13], a layered structure in the cartilage [14], distinct domains in bone [15], etc.

Magnitude, rather than complex MRI signals, is widely used in quantitative MRI studies. This choice is primarily due to the fact that the phase of MRI signals is sensitive to many experimental factors, such as scanner type, field inhomogeneity, temperature, coil type, pulse sequence design, motion, etc. [16–19]. While magnitude MRI is preferred in relaxation

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