An Atlas-based Variational Approach to Quantitative Susceptibility Mapping
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Introduction
Excessive iron deposition in specific regions of the brain is associated with neurodegenerative disorders such as Alzheimer's and Parkinson's disease [1]. Iron deposition causes changes in tissue magnetic susceptibility, resulting in magnetic field perturbations that can be modeled as the convolution of a dipole-like kernel and the spatial susceptibility map. In the Fourier domain, zeros at the magic angle and limited observations make inversion of the field ill-posed. In addition, "biasfields" from external sources (i.e., tissue/air boundaries, mis-registered images) confound iron-related phase effects. Previous work has shown that a wave equation relating the Laplacian of the field to the D'Alambertian of susceptibility can be derived from a spatial formulation of the forward model, providing biasfield elimination and accurate susceptibility estimates when solved with a variational approach [2]. In this work, we present an atlas-based susceptibility mapping (ASM) technique that is based on the Laplacian of the spatial field model and incorporates a tissue/air atlas to resolve ambiguity between internal and external susceptibility sources.

Methods
Quantitative susceptibility mapping (QSM) is a challenging problem because operations on susceptibility, such as the kernel, K, or the D'Alambertian, ∇², cause information loss due to derivatives in 0 or zeros in the kernel, requiring some form of regularization or prior information for a complete solution. Probabilistic atlases are frequently used to compensate for missing information in MR acquisitions: in [3] it was shown that use of a tissue/air susceptibility atlas improves forward field calculations. Although [2] showed good results for phantom data, the regularization term assumed very similar spatial information in MR acquisitions: in [3] it was shown that use of a tissue/air susceptibility atlas improved forward field calculations. Although [2] showed good results for phantom data, the regularization term assumed very similar spatial information in MR acquisitions: in [3] it was shown that use of a tissue/air susceptibility atlas improves forward field calculations.

Fig 1. shows the average ASM results for young and elderly subjects, illustrating an age-dependent increase in iron concentration in sub-cortical structures. Mean susceptibility in both elderly and young subjects shows strong correspondence with postmortem iron concentrations (mg/100g) in young and elderly subjects.

References:

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![Fig 1](image1.png)

![Fig 2](image2.png)