Validation of Diffusion Tensor Imaging

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Introduction

The ability of MR techniques to generate images that represent the apparent tracks of the fibers in the brain has been of great excitement in neurological sciences over the last few years. A variety of diffusion tensor imaging (DTI) techniques have been developed and are in the process of being evaluated and applied. The intrinsic problem in defining the tracks is driven by the low sensitivity of MRI. To combat this, a large variety of postprocessing and analysis techniques are being developed that purport to 'improve' the DTI data sets. In particular a great deal of effort is expended in trying to separate crossing fibers and follow the fine tracks through the brain. The major difficulty with these DT images is that validation, especially in the human brain, is problematic. Even if a volunteer were found, imaged and extinguished, accurate correlative histology is non-trivial, if not unfeasible. Consequently, the validation issue has been mysteriously and conveniently side stepped. In this study, we illustrate the problem with a few examples of established DTI techniques and some new processing algorithms, producing generally arbitrary results.

Methods and Results

First, we implemented the standard HARDI (1) imaging technique on our eleventeen Tesla headscanner on a semi-willing volunteer. The first data sets were acquired with optimized resolution and SNR to obtain the finest detail data sets for subsequent processing. In order to test the accuracy of these algorithms under less optimal (and practical) conditions, the image quality was reduced. Initially this was achieved by using Serially Optimized Fractal Tensor Imaging (SOFTI), but we stepped back from this approach when we were teased at a conference presentation and had sand thrown onto the poster. Instead, we took an alternative approach, combining HARDI with Low Angle Under Resolved Echo Lengthening (LAUREL & HARDI); that was much more fun. Figure 1 shows the intrinsic problem in interpreting DTI data, showing the results of four different algorithms applied to the data. All produce apparently valid but quite different fiber maps.

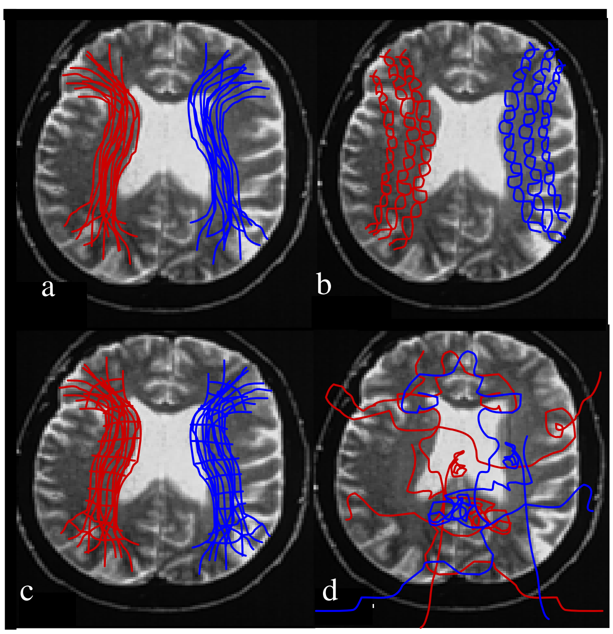

Figure 1. Fiber track maps from two bilateral seeding points generated using four data processing algorithms.
(1a) conventional DTI
(1b) Phase Lateralization and Tensor Tightening, – PLATT,
(1c) Multiple Echo Square Hopping – MESH, and
(1d) Diffusing Under the Influence – DUI.

Discussion.

Studies are ongoing developing a new correlative technique, TDI, that provides a more practical approach to defining a suitable processing algorithm revealing 3D fiber structure, using more reliable manual rather than automated techniques. Realizing that validation still remains a major stumbling block even with this new approach, we also propose a revolutionary new technique, Nauti-DTI. Ultimately, our results do nothing to help validate DTI itself, but we hope to show that although complex development of new DTI procedures is painful, ultimately this kind of research is a pleasure.