Creating a Streamlined Pipeline Utility for the Analysis of Universal Diffusion Tensor Imaging Data

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What is MIPAV?

- Medical Image Processing, Analysis, and Visualization
- Created by the Biomedical Imaging Research Services Section (BIRSS) of the Center for Information Technology (CIT)
- Enables quantitative analysis and visualization of medical images from numerous modalities (i.e. PET, MRI, CT, microscopy)

http://mipav.cit.nih.gov
MIPAV Goals

• Develop computational methods and algorithms to analyze and quantify biomedical data

• Establish collaborations with NIH researchers and colleagues at other research centers

• Provide needed tools (in both hardware and software) to support the discovery and advancement of biomedical knowledge.

http://mipav.cit.nih.gov
Conventional Magnetic Resonance Imaging vs. Diffusion Tensor Imaging

**MRI**
- Directly constructs an image of soft tissue in the body by using magnetic fields
- In the brain, MRI shows distinction between white and gray matter
  - Does not show fine detail of the white matter (neuronal tracts)

**DTI**
- Determines directionality and magnitude of water diffusion in the brain
  - This information is used to calculate fiber tract anatomy located in the white matter

http://lmi.bwh.harvard.edu

http://www.alliancemedical.co.uk
Importance of Protons in MRI

• MRI images are primarily derived from the hydrogen protons (H+) found in water

• Water is found in 70% to 90% of most body tissue and alters dramatically with disease and injury

• Protons become magnetized when immersed in an externally applied static field ($B_0$)
Fundamentals of MRI

$B_0$ - Magnetic field

H+ - Protons

* - Short RF pulse

Decaying Signal (FID)

X, Y, and Z gradients localize RF to allow “slices” of the body to be created

Lamor freq = $B_0 \times$ gyromagnetic constant

Relaxation times are tissue dependent

http://www.magnet.fsu.edu
Diffusion Tensor Imaging

MRI Imaging modality that indirectly images fibrous white matter brain tissue (nerve axons) by detecting water diffusion that tends to occur anisotropically along the nerve fibers.

http://www.alliancemedical.co.uk
Advantages of DTI

• Non-invasive

• Can measure water diffusion along any oblique angle

• Reveals detailed anatomy of white matter through fiber orientations
  – MRI cannot view detailed anatomy due to white matter homogeneity in chemical composition

• Improves understanding of connectivity
In the absence of diffusion, a rephasing gradient brings the spins back in phase. (no signal loss)
Computation of Diffusion Tensor and Applications

- **Requirements for Tensor Calculation:**
  I. A minimum of 7 scans from various directions
     - The first scan should be without the application of gradients with the $B_0$ set to zero
  II. Registration of the other scans in the Diffusion Weighted Imaging (DWI) data set to the first scan
  III. Distortion correction

- **MIPAV Tensor Calculation Applications:**
  I. Fiber Tracking
  II. Visualization
Current MIPAV DTI Pipeline
New MIPAV DTI Pipeline Project
to create a user-friendly DTI pipeline that has universal processing for all Diffusion Weighted Imaging (DWI) datasets acquired from any MRI scanner (i.e. Philips, Siemens, and GE)
New MIPAV DTI Pipeline Project

1. Motion Correction

Registration

Post-processing MIPAV DTI Pipeline
1. Tensor Calculation
2. Fiber Tracking
3. Visualization

Siemens (DICOM Mosaic)
GE (DICOM)
Philips (DICOM, PAR/REC)

Model Image

DTI Parameters Object

Distortion Correction
Completed MIPAV DTI Pipeline Steps

3D Mosaic to 4D Volume Utility

DTI Tab
- Automatic Population of Gradient/Bvalue Table for various image types
- Ability to save DTI parameters with image to be used for tensor calculation, fiber tracking, and visualization
- Save bvalue and gradient table to different text formats

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The Import Data Step
Current MIPAV DTI Pipeline
Next Step

Create an integrated DTI dialog incorporating all the steps of the pipeline including pre-processing and post-processing steps.
The Fornix Sign: A Potential Sign for Alzheimer's Disease Based on Diffusion Tensor Imaging.


Fig 1. Example of the fornix sign. The axial (left), coronal (middle), and sagittal (right) slices of the color-scaled FA map are shown with the magnified view of the fornix (yellow rectangle). (A) FA map of a cognitively normal 80-year-old woman without a fornix sign. The core part of the fornix appears yellow to red (FA .5-.8). (B) FA map of an 80-year-old woman with Alzheimer's disease with the fornix sign. The fornix appears green (FA < .5). FA = fractional anisotropy.
References

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