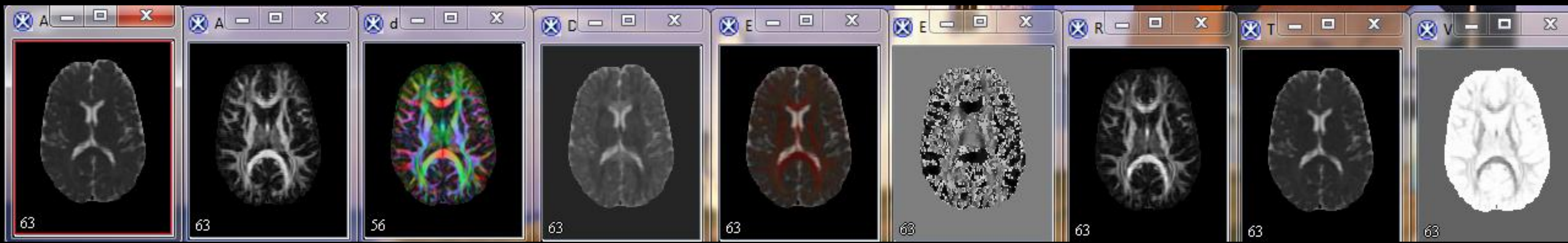


Creating a Streamlined Pipeline Utility for the Analysis of Universal Diffusion Tensor Imaging Data

Beth Tyrie

October 20, 2011

What is MIPAV?

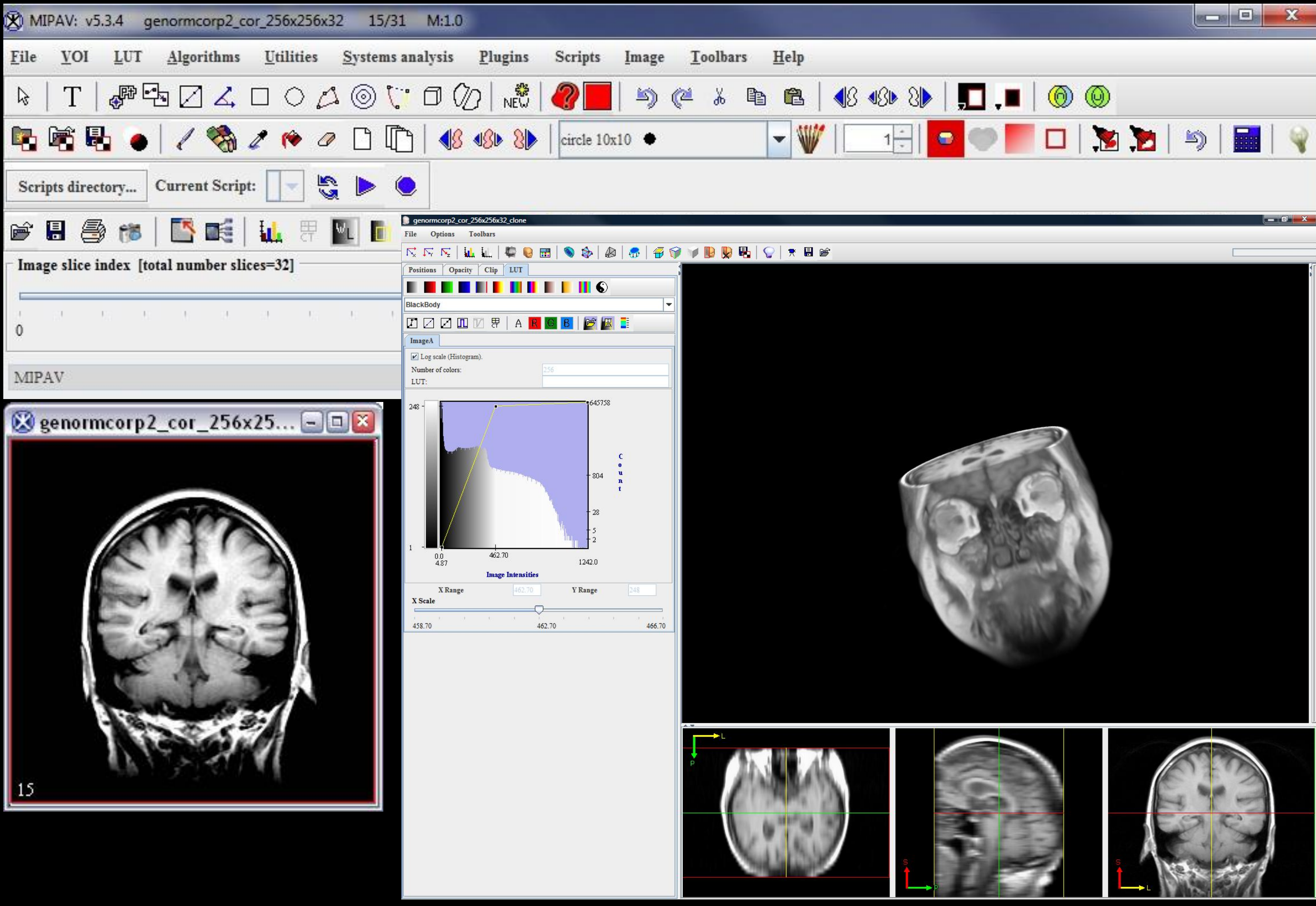
- Medical Image Processing, Analysis, and Visualization
- Created by the Biomedical Imaging Research Services Section (BIRSS) of the Center for Information Technology (CIT)
- Enables quantitative analysis and visualization of medical images from numerous modalities (i.e. PET, MRI, CT, microscopy)

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.

MIPAV Interface



Conventional Magnetic Resonance Imaging vs. Diffusion Tensor Imaging

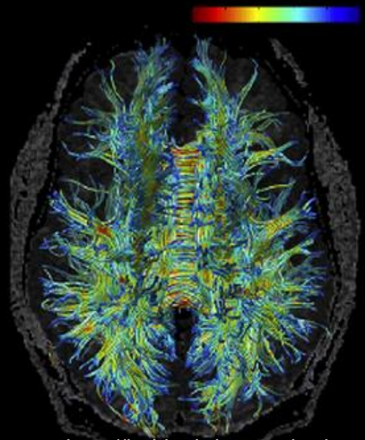
MRI

- 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)


http://www.alliancemedical.co.uk

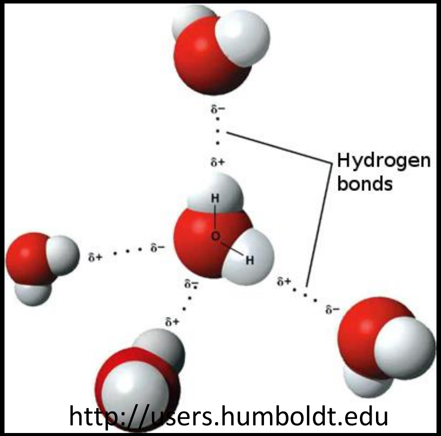
DTI

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

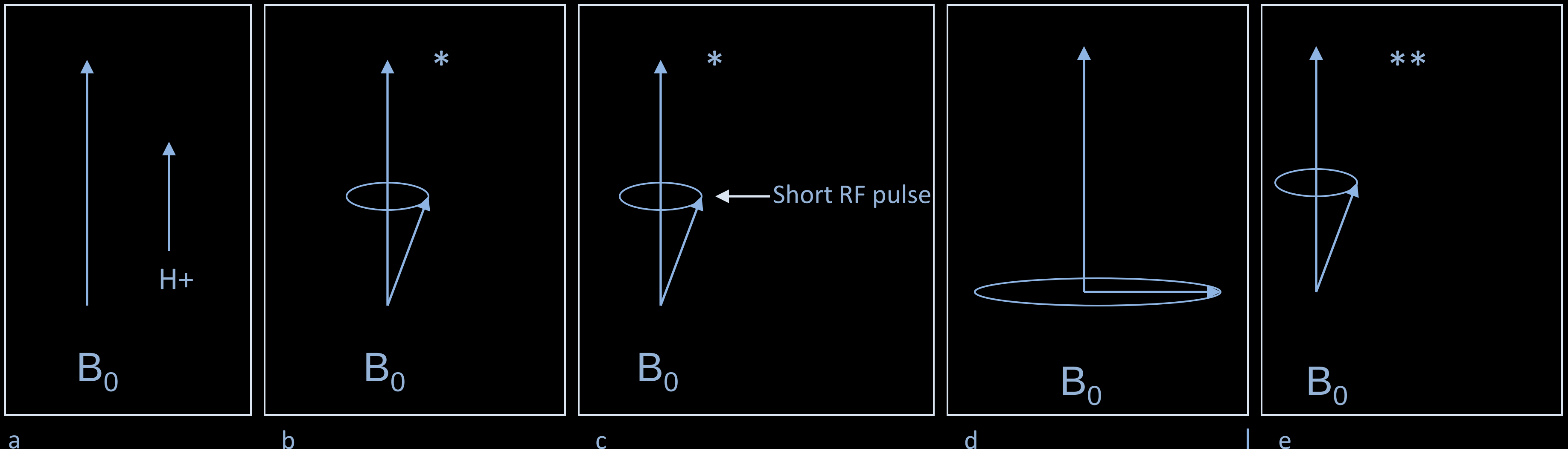

http://lmi.bwh.harvard.edu

Importance of Protons in MRI

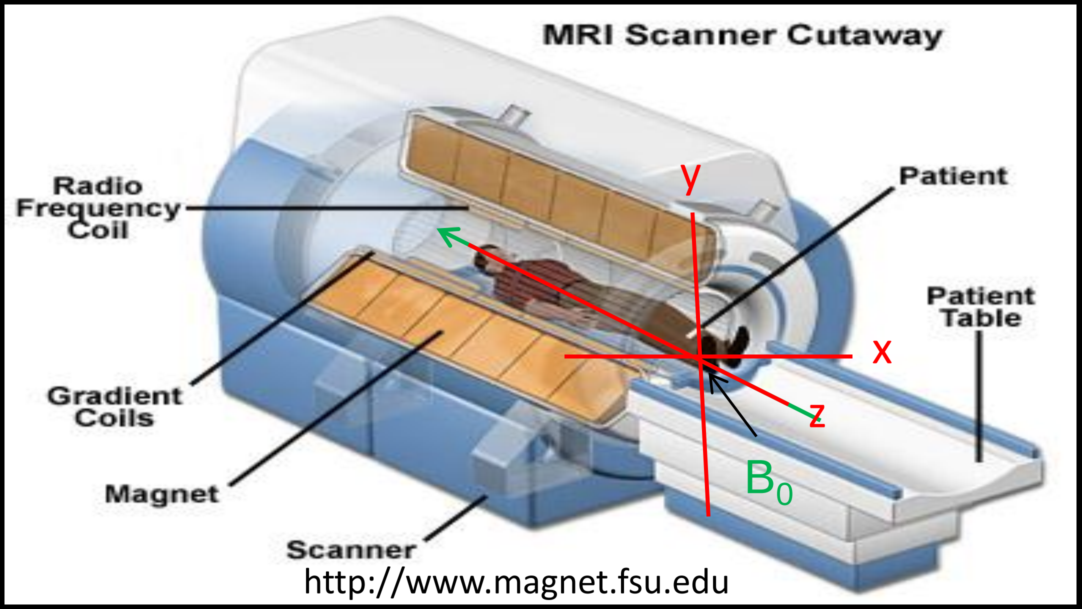
- MRI images are primarily derived from the hydrogen protons (H+) found in water
- Water is found in 70% to 90% of most body tissue and alters dramatically with disease and injury
- Protons become magnetized when immersed in an externally applied static field (B_0)



Fundamentals of MRI



Decaying Signal (FID)



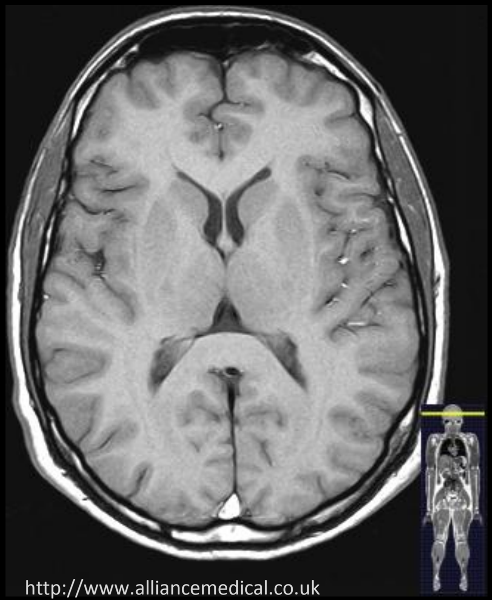
X, Y, and Z gradients localize RF to allow “slices” of the body to be created

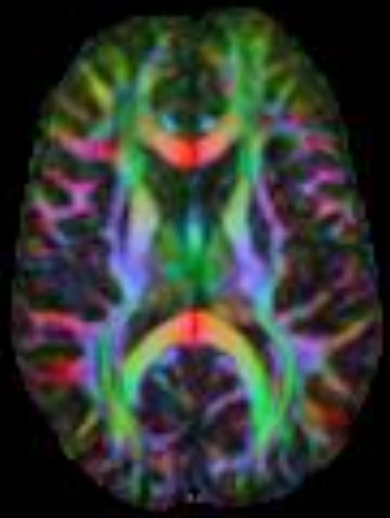
* Lamor freq = B_0 x gyromagnetic constant

** Relaxation times are tissue dependent

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.

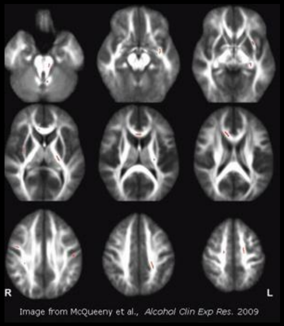




Advantages of DTI

- Non-invasive

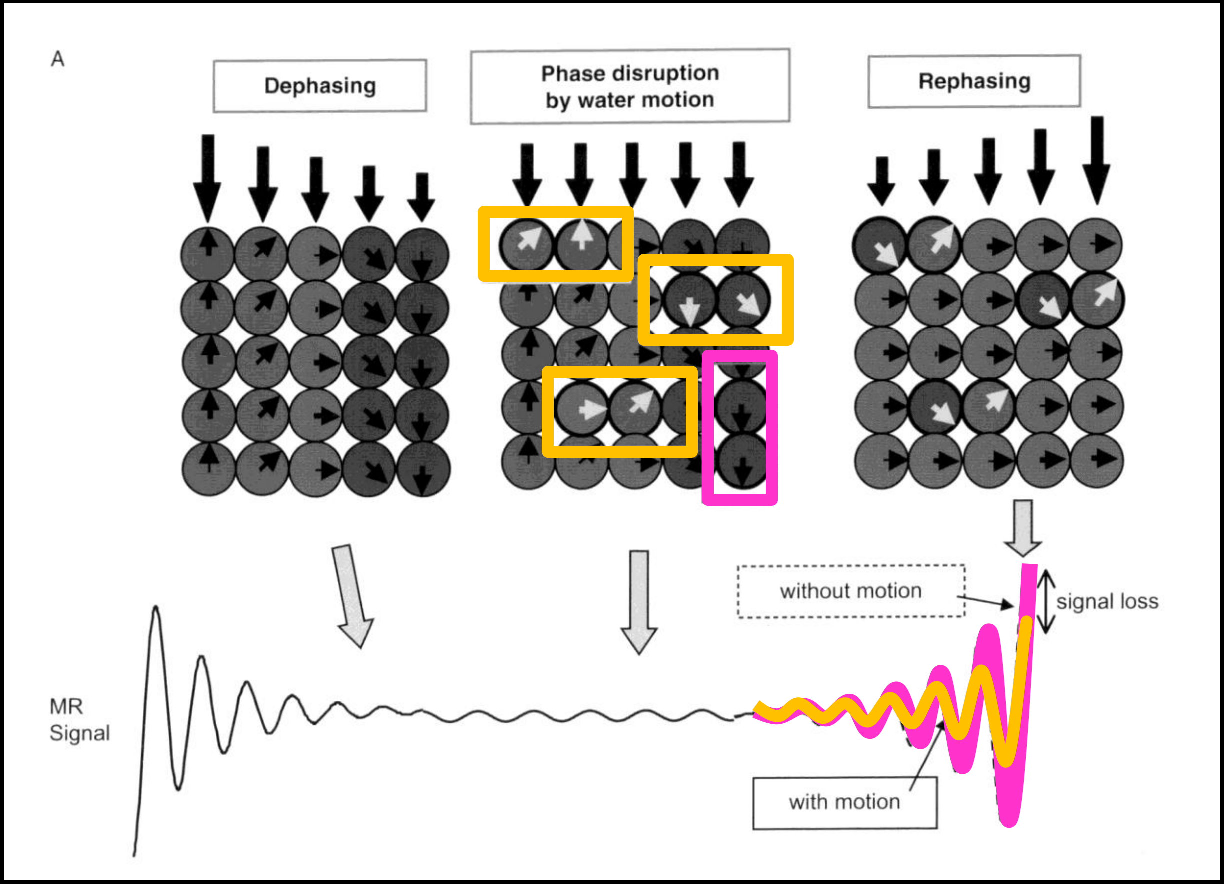
- Can measure water diffusion along any oblique angle
- Reveals detailed anatomy of white matter through fiber orientations
  - MRI cannot view detailed anatomy due to white matter homogeneity in chemical composition



- Improves understanding of connectivity

http://www.humanconnectomeproject.org

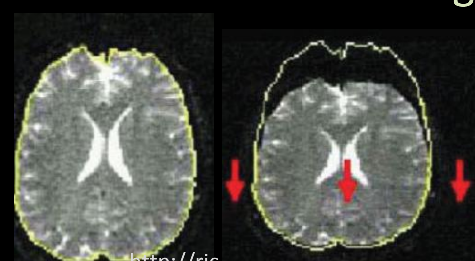
Sensitizing the MRI Scan to Water Diffusion



In the absence of diffusion, a rephasing gradient brings the spins back in phase. (no signal loss)

Computation of Diffusion Tensor and Applications

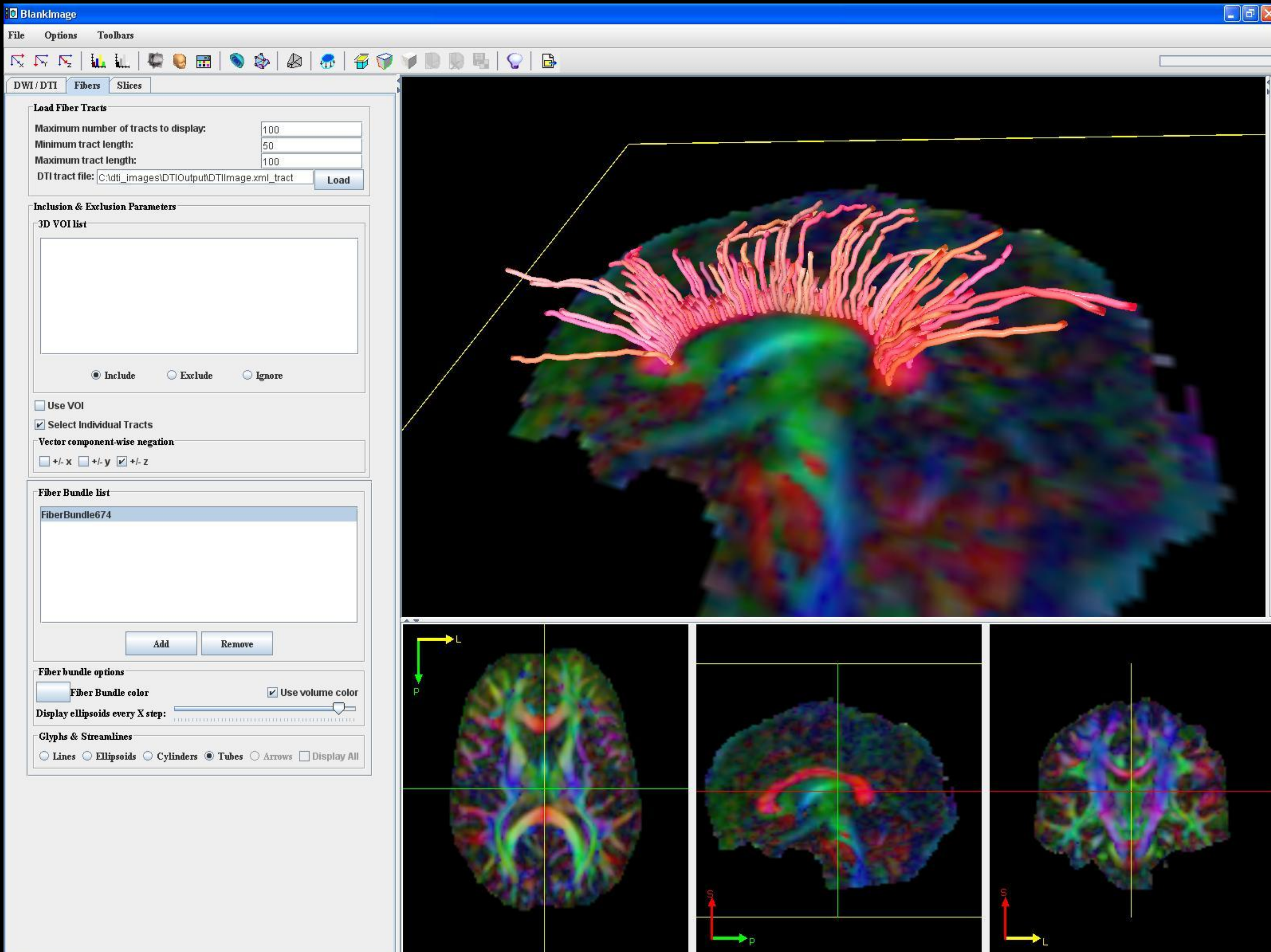
- Requirements for Tensor Calculation:
  I. A minimum of 7 scans from various directions
     - The first scan should be without the application of gradients with the B_0 set to zero
  II. Registration of the other scans in the Diffusion Weighted Imaging (DWI) data set to the first scan
  III. Distortion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



http://ric

- MIPAV Tensor Calculation Applications:
  I. Fiber Tracking
  II. Visualization

http://tecnologiayciencia.es


BlankImage
File
Options
Toolbars
DWI / DTI
Fibers
Slices
Load Fiber Tracts
Maximum number of tracts to display:
100
Minimum tract length:
50
Maximum tract length:
100
DTI tract file:
C:\dti_images\DTIOutput\DTIImage.xml_tract
Load
Inclusion & Exclusion Parameters
3D VOI list
Include
Exclude
Ignore
Use VOI
Select Individual Tracts
Vector component-wise negation
+/- x
+/- y
+/- z
Fiber Bundle list
FiberBundle674
Add
Remove
Fiber bundle options
Fiber Bundle color
Use volume color
Display ellipsoids every X step:
Glyphs & Streamlines
Lines
Ellipsoids
Cylinders
Tubes
Arrows
Display All
L
P
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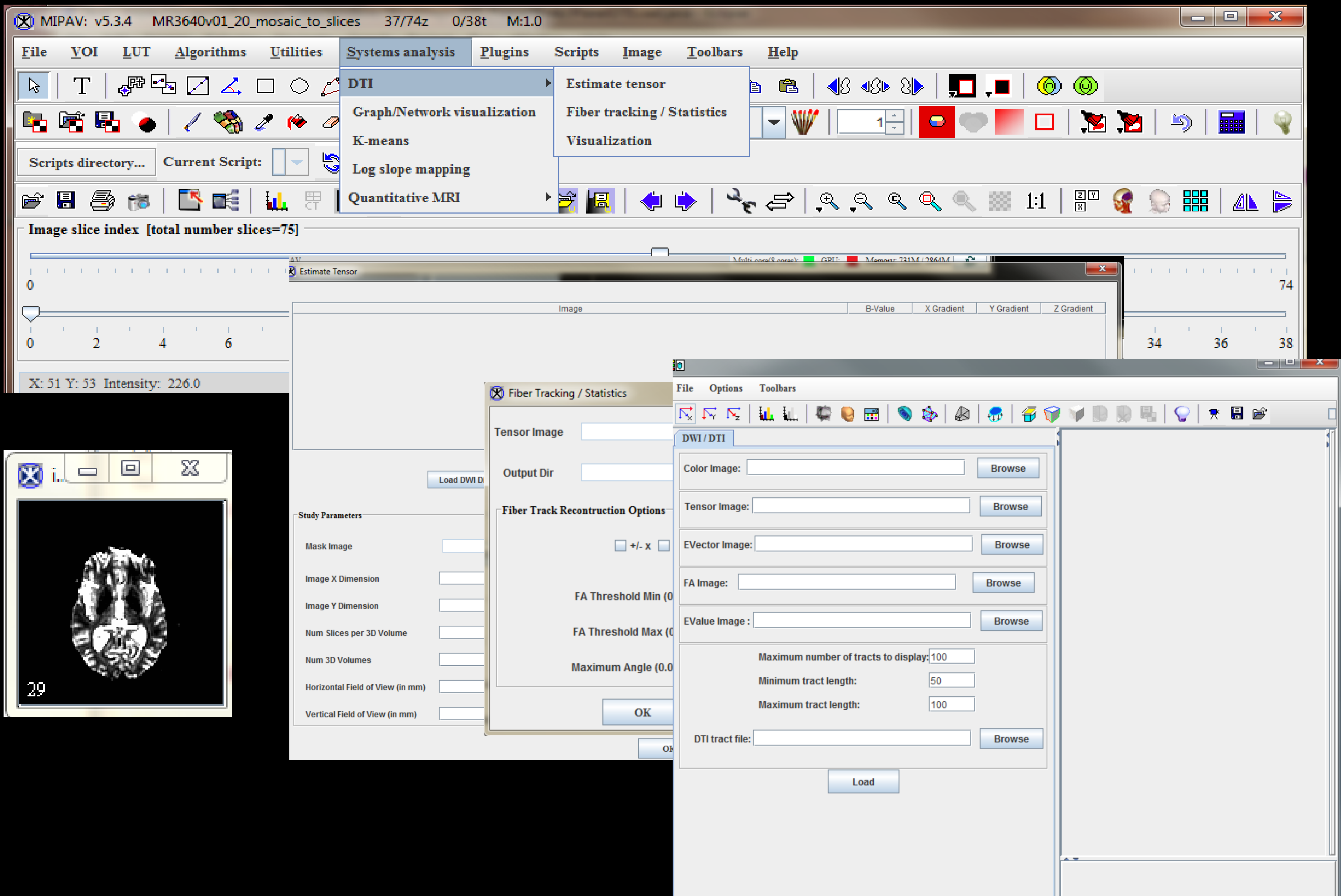
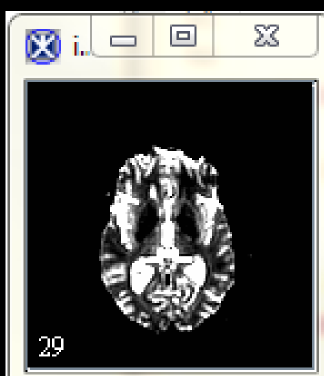
S
L

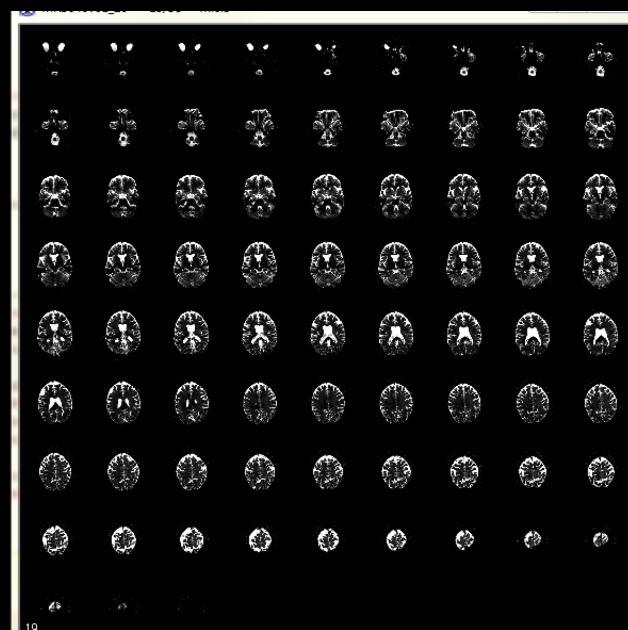
Current MIPAV DTI Pipeline

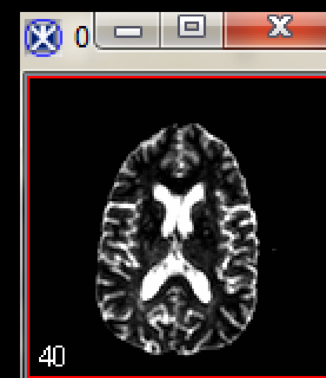


New MIPAV DTI Pipeline Project

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

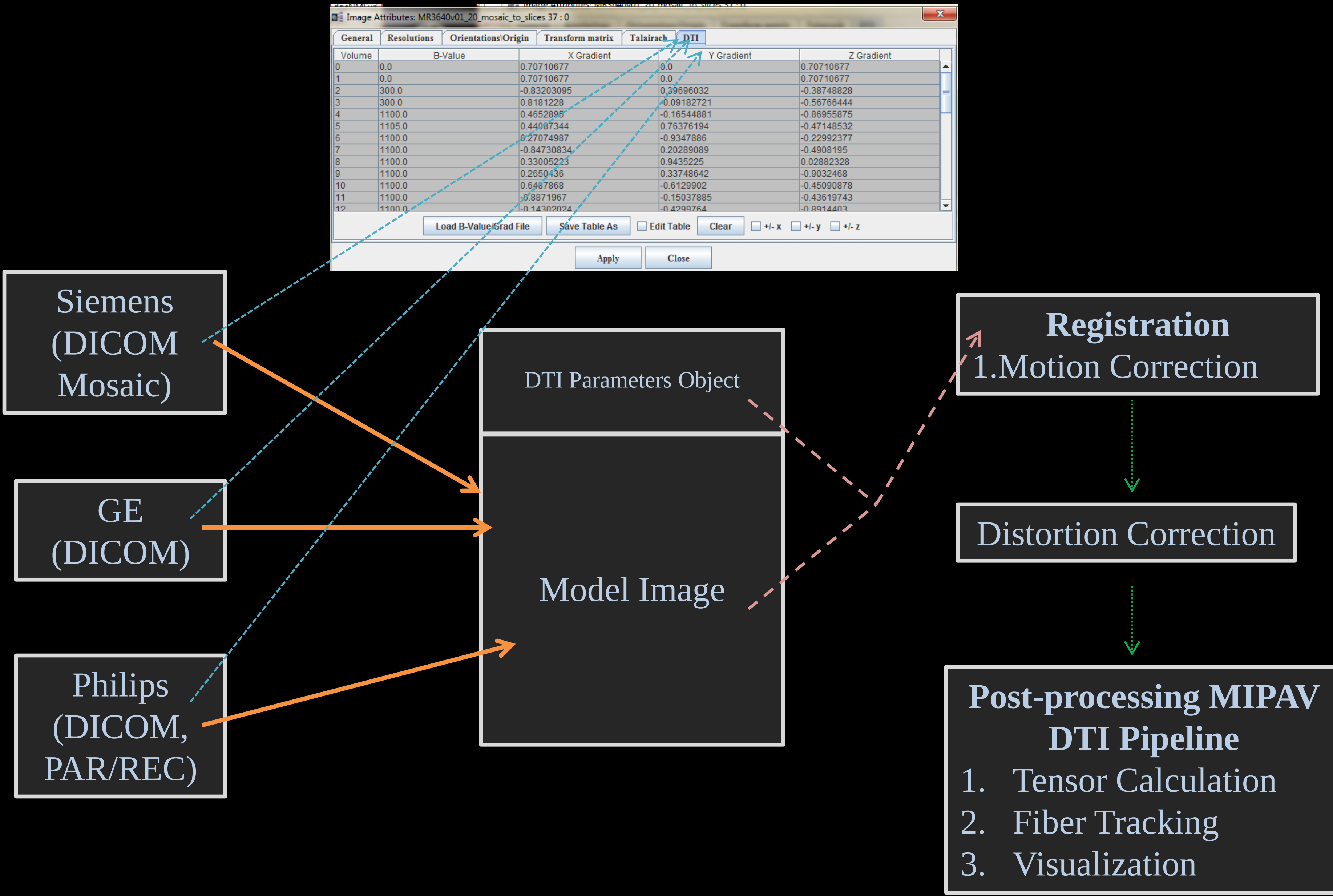


Image Attributes: MR3640v01_20_mosaic_to_slices 37 : 0

General | Resolutions | Orientations\Origin | Transform matrix | Talairach | DTI

Volume	B-Value	X Gradient	Y Gradient	Z Gradient
0	0.0	0.70710677	0.0	0.70710677
1	0.0	0.70710677	0.0	0.70710677
2	300.0	-0.83203095	0.39696032	-0.38748828
3	300.0	0.8181228	-0.09182721	-0.56766444
4	1100.0	0.4652895	-0.16544881	-0.86955875
5	1105.0	0.44087344	0.76376194	-0.47148532
6	1100.0	0.27074987	-0.9347886	-0.22992377
7	1100.0	-0.84730834	0.20289089	-0.4908195
8	1100.0	0.33005223	0.9435225	0.02882328
9	1100.0	0.2650436	0.33748642	-0.9032468
10	1100.0	0.6487868	-0.6129902	-0.45090878
11	1100.0	-0.8871967	-0.15037885	-0.43619743
12	1100.0	-0.14302024	-0.4299764	-0.8914403

Load B-Value/Grad File | Save Table As | Edit Table | Clear | +/- x | +/- y | +/- z

Apply | Close

Completed MIPAV DTI Pipeline Steps

3D Mosaic to 4D Volume Utility

DTI Tab

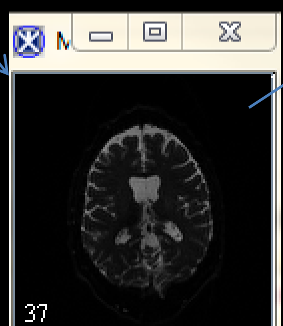
- Automatic Population of Gradient/Bvalue Table for various image types

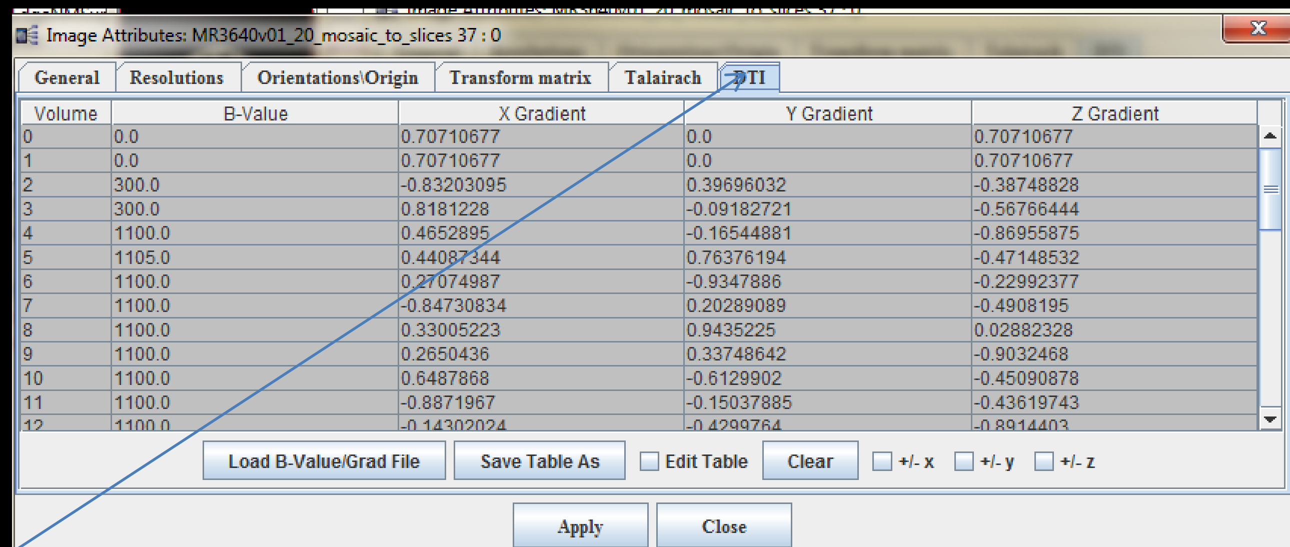
File Type	Auto Pop of Bvals	Auto Pop of Grads
Philips P/R V3 & V4	✓	×
Philips P/R V4.1+	✓	✓
Siemens Mosaic DCM	✓	✓
GE DCM	?	?
Philips V4.1+ DCM		
fsl.txt	✓	✓
dtiStudio.txt	×	✓
mipavStandard.txt	✓	✓

- 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

The Import Data Step





Volume	B-Value	X Gradient	Y Gradient	Z Gradient
0	0.0	0.70710677	0.0	0.70710677
1	0.0	0.70710677	0.0	0.70710677
2	300.0	-0.83203095	0.39696032	-0.38748828
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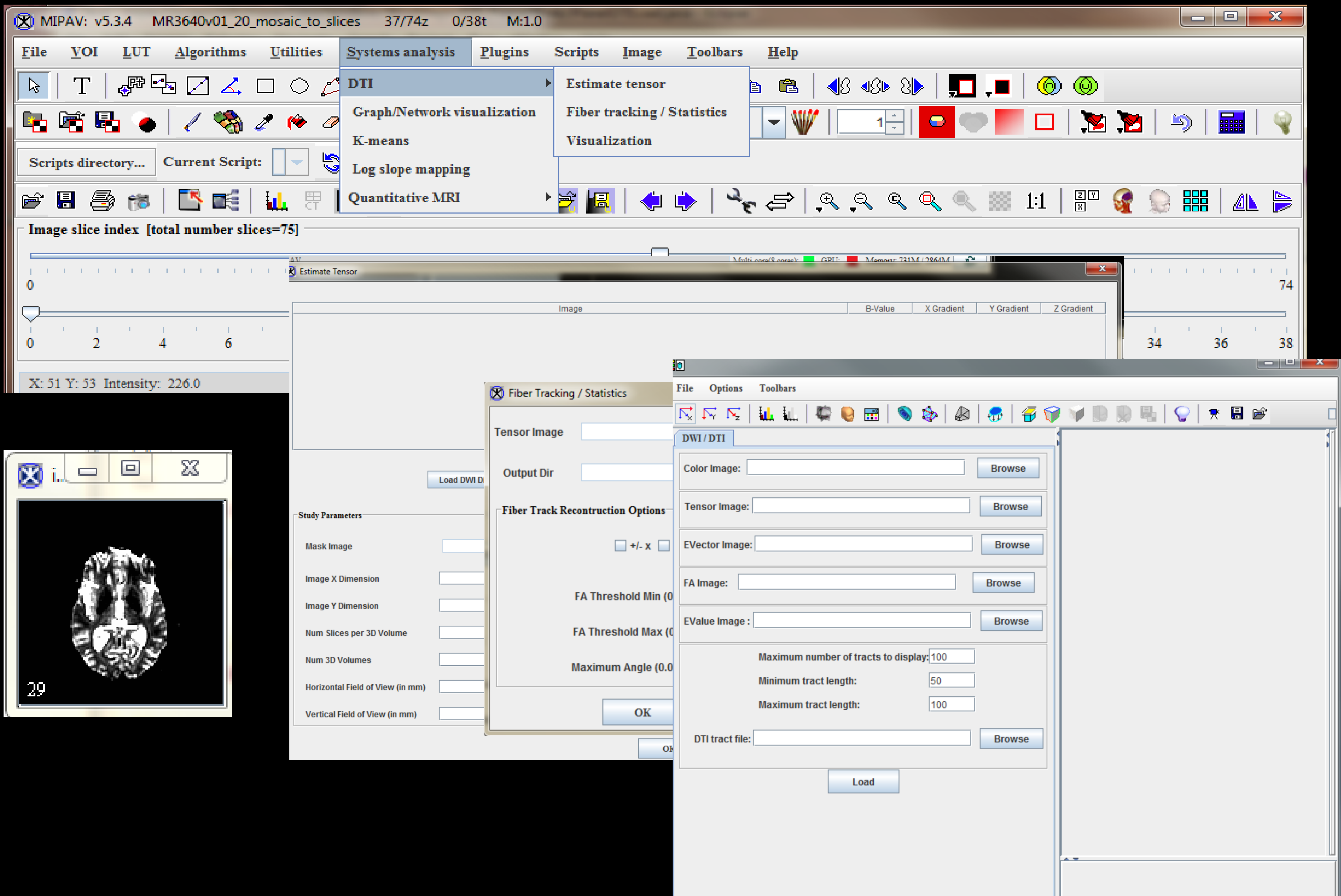
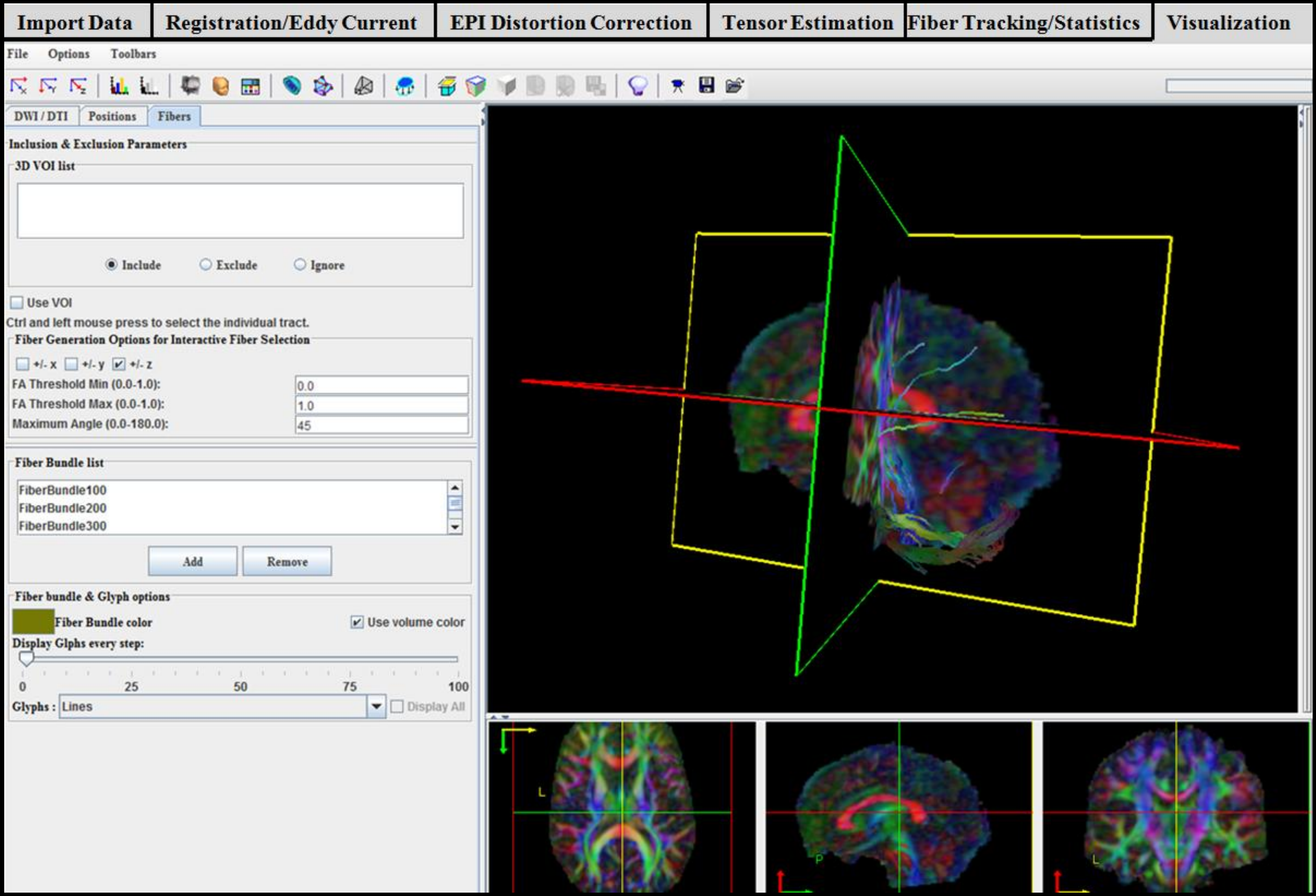
11	1100.0	-0.8871967	-0.15037885	-0.43619743
12	1100.0	-0.14302024	-0.4299764	-0.8914403

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.

Oishi K, Mielke MM, Albert M, Lyetsos CG, Mori, S (2011) J Neuroimaging. 1552-6569

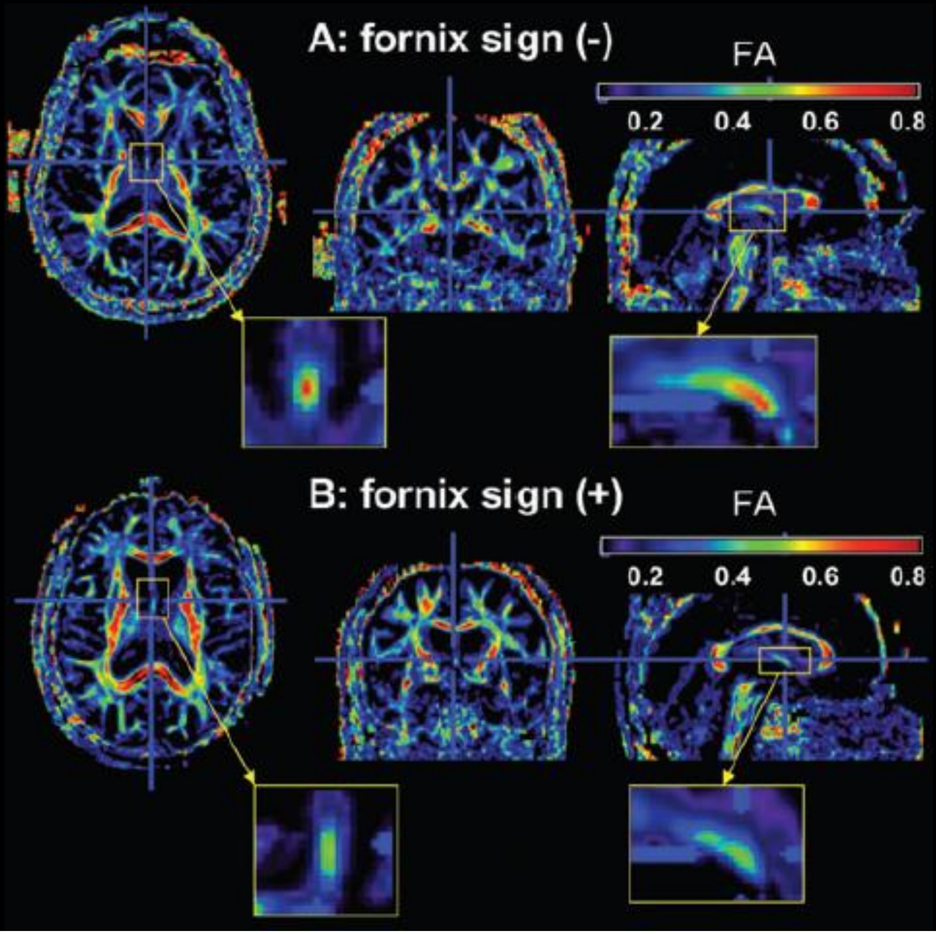


Fig 1. Example of the fornix sign. The axial (left), coronal (middle), and sagittal (right) slices of the color-scaled FA map are shown with the magnified view of the fornix (yellow rectangle). (A) FA map of a cognitively normal 80-year-old woman without a fornix sign. The core part of the fornix appears 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

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

Oishi K, Mielke MM, Albert M, Lyetsos CG, Mori S (2011) The Fornix Sign: A Potential Sign for Alzheimer's Disease Based on Diffusion Tensor Imaging. J Neuroimaging. 1552-6569

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