

AFNI Diffusion Plugin Users Guide

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Chapter 1. Introduction

The AFNI Diffusion Plugin (ADP) is a software package developed by the Center for Scientific Computation in Imaging at UCSD to extend the functionality of AFNI to analyze and visualize diffusion tensor imaging (DTI) data. ADP provides tools to convert diffusion weighted imaging data into the standard diffusion tensor (with fractional anisotropy and mean diffusion included) as well as a spherical harmonic decomposition (SHD) of the diffusion signal. The SHD is able to capture diffusion modes lost to the standard second order diffusion tensor, which preserves information about anisotropy in regions of crossing or fanning fibers.

The AFNI Diffusion Plugin also provides a three-dimensional cut plane viewer which shows not only anatomical images, but also diffusion data, displayed as vectors pointing in the direction of the primary eigenvector of the diffusion tensor. The vectors are colored according to local fractional anisotropy (FA) and may also be thresholded according to FA.

Finally, the AFNI Diffusion Plugin provides a display of the diffusion signal for any selected voxel (chosen by crosshairs in the standard AFNI viewer).

Chapter 2. Installation

2.1. Prerequisites

The list of prerequisites for this software is fairly intimidating, but perhaps still not complete. Please let us know if a dependency is missing.

- AFNI. You will need the source code, not just a binary distribution.
- Motif. AFNI will build with lesstif, but you will notice strange things here and there, and occasional crashes have been reported.
- VTK. The current version of the plugin should build with any version of VTK from 4.2 through 5.0 (and beyond). Some features are degraded with versions prior to 5.0, however, so we recommend newer versions. Our plugin assumes that you have built shared library support in VTK, though, so be sure to enable that when you configure your build.
- GSL. The GNU Scientific Library is probably also available as a pre-built package for your Linux distribution.

2.2. Download

The source code is available for download from the following address:

<http://grover.ucsd.edu/afni-diff-plugin/afni-diff-plugin.tar.gz>

2.3. Building AFNI and the Plugin

After downloading and unpacking the source code for the AFNI Diffusion Plugin and for AFNI itself and installing the other necessary prerequisites, you are ready to build AFNI and the Diffusion Plugin. At this time, you will need to build a special version of the AFNI executable, afni++, in order to use the AFNI Diffusion Plugin. Fortunately, the build process itself is fairly simple. Change into the diffusion plugin directory:

```
cd <afni-plugin-directory>
```

Now we need to configure some settings for the build:

```
./configure --with-afni=<your-afni-directory> --with-vtk=<location-of-vtk> \  
--with-libXm=<location-of-libXm.a>
```

The following commands will complete the build process:

```
make
cd <your-afni-directory>
make
```

2.4. Setting AFNI Environment Variables

After installing AFNI and the AFNI Diffusion Plugin, you will need to set a few environment variables so that applications and plugins can be found automatically. If you are using bash as your shell (the default on most Linux machines¹), the following commands—modified to include your specific path information—will set the necessary variables:

```
export AFNI_PLUGINPATH=<your-afni-directory>/linux_g++
export PATH=$PATH:$AFNI_PLUGINPATH
```

Notes

1. If your shell is a csh variant (csh or tcsh), you will need to use the `setenv` command:

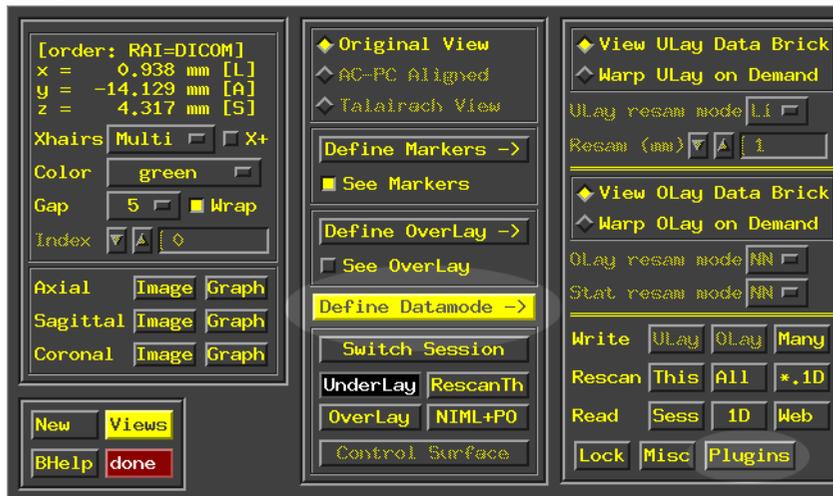
```
setenv AFNI_PLUGINPATH <your-afni-directory>/linux_g++
setenv PATH $PATH:$AFNI_PLUGINPATH
```

Chapter 3. Examining and Analyzing Diffusion Data

With AFNI and the AFNI Diffusion Plugin installed, you're ready to analyze some data. You can either start with our sample data set (please contact gballs@ucsd.edu to request it), or create one of your own using the *edif2afni* script.

With your environment variables properly set (see *Setting AFNI Environment Variables*), the newly built AFNI program can be started by running **afni++**.

To access the AFNI Diffusion Plugin, first open the "Define Datamode" menu and then click the "Plugins" button:

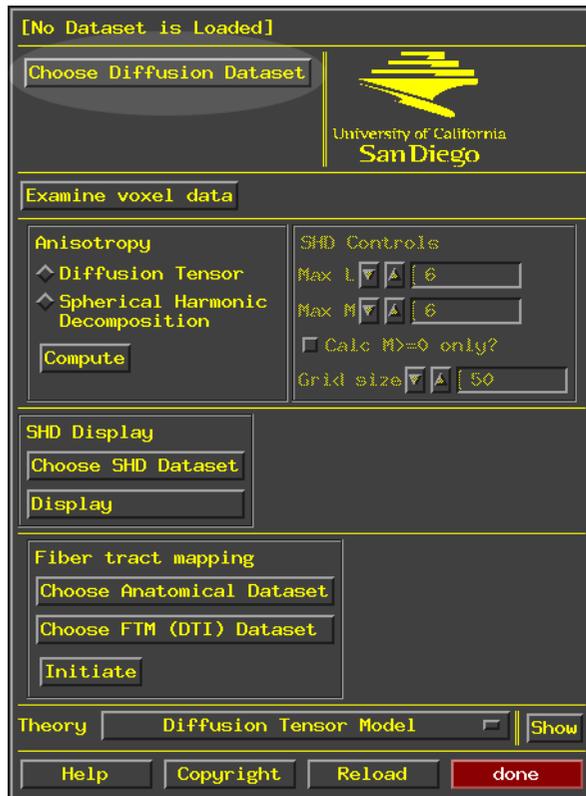


The Diffusion plugin appears along with all the other standard plugins:



3.1. Choosing a Dataset

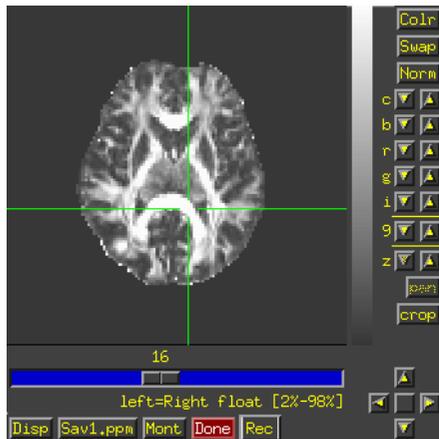
Now that you've opened the diffusion plugin, the first thing to do is choose the diffusion dataset to analyze:



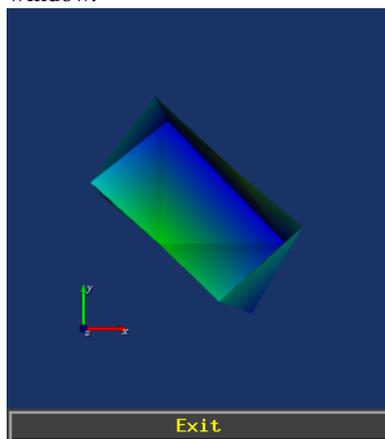
From the drop-down menu, select the DWI dataset you wish to analyze and click the "Set" button.

3.2. Examining Voxel Data

We can examine the signal in each voxel. The "Examine voxel data" button opens a new window, which is empty at first, except for the orientation axes. In the main AFNI window, choose a dataset with the same size and geometry (preferably the original dataset or one calculated from it), and open one of the image windows. The image below is a fractional anisotropy map calculated from our diffusion dataset (see *Calculating the Diffusion Tensor and Anisotropy Metrics* for more information about how to generate an FA map).



After selecting a point in the AFNI image window, the signal for that point is shown in the signal window.



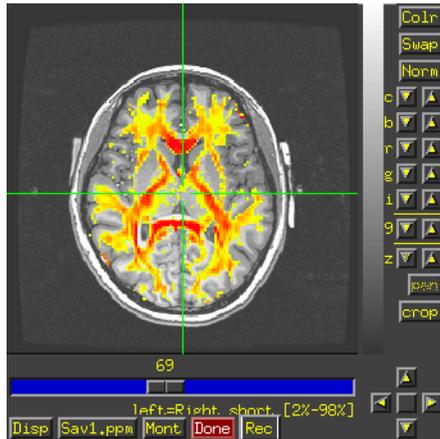
The signal is represented as a polygon with points along the gradient directions at a distance proportional to the signal for that direction. The polygon is colored by distance from the origin.

3.3. Calculating the Diffusion Tensor and Anisotropy Metrics

The diffusion tensor and spherical harmonic decomposition can be calculated directly from the plugin interface. Select either "Diffusion Tensor" or "Spherical Harmonic Decomposition" in the "Anisotropy" box and click the "Compute" button. These calculations can take a while, so please be patient.

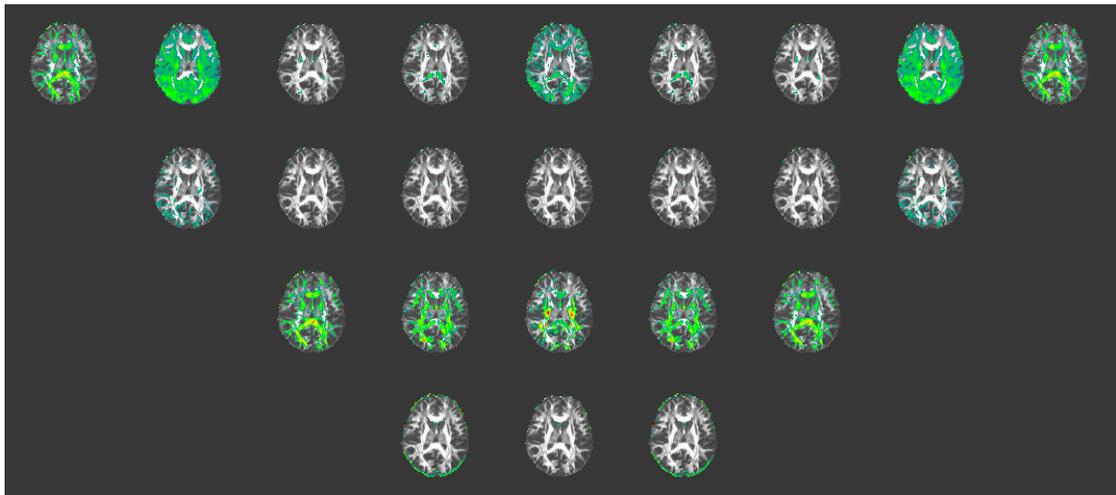
The Diffusion Tensor calculation calls AFNI's 3dDWtoDT routine to calculate the diffusion tensor, its eigenvectors and eigenvalues, as well as the fractional anisotropy and mean diffusion. The new BRIK is given a name with ".DTI" appended and is automatically selected as the overlay in the main AFNI

window. The following image shows the FA calculated in this manner as an overlay on an anatomical image.



For the Spherical Harmonic Decomposition, it is necessary to select a maximum level, L , for the calculation. Level 2 contains the same amount of information as the standard diffusion tensor. Odd levels are unphysical, so any signal in these levels is due to noise in the original dataset. Level 4 spherical harmonics represent some of the higher frequency harmonics that may correspond to types of anisotropy not well resolved by the standard diffusion tensor. Obtaining useful results for higher levels requires a large number of gradient directions in the original diffusion weighted scan. (Eventually the maximum level will be chosen automatically to minimize error.)

Once you have calculated the Spherical Harmonic Decomposition, you can view the components in a montage. Select the SHD dataset using the "Choose SHD Dataset" button, and then click "Display". The following image shows a montage of an SHD dataset over FA for the same dataset.



Note: The montage display currently only works with an underlay of the same geometry as the SHD. Also, there is no option for selecting the subbrick shown as the underlay: the first subbrick is always used. Finally, only axial views are functional at this point.

Appendix A. edif2afni

To be completed.