Recent Developments with 3D Slicer related to Neurosurgical Applications

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Introduction

The following summarizes developments since October 2004 that are significant for neurosurgical applications of 3D Slicer. Most of these became available in Slicer version 2.4 which was released in January 2005.

Background

For IGT, Slicer is frequently used to construct and visualize collections of data that are available pre- and intra-operatively (see Figure 4). In addition to conventional MRI and associated 3D Models, Slicer has been used to present information derived from fMRI, DTI, and Electro-Corticography performed with tracked probes. The following material describes developments in those areas.

fMRI Data Analysis in Slicer

fMRI data analysis capabilities have become available in Slicer V2.4. This has several implications for neurosurgical applications. Keeping the fMRI data analysis in the Slicer environment will facilitate the maintenance of correct registration among the functional and anatomical information. In addition, it will be easier to add non-standard activation processors, that are, for example, aimed at increased delineation accuracy.

These capabilities are currently implemented in two tools, *interval browser*, and *fMRI engine*. The interval browser provides a convenient tool for interacting with time series of volumetric images, in general. Figure 1 illustrates Ibrowser operating on a series of echo-planar MRI.

After loading, activation detection can be carried using the fMRI Engine, which supports the following:

- Data loading: Loads Analyze (3D and 4D), DICOM, BXH (BIAC XML Header) format data; or imports from Interval Browser
- Protocol specification: input block design via GUI or load/save in text file
- Activation computing: GLM detection, currently supports block design protocol with single regressor

Figure 2 illustrates activation detection.

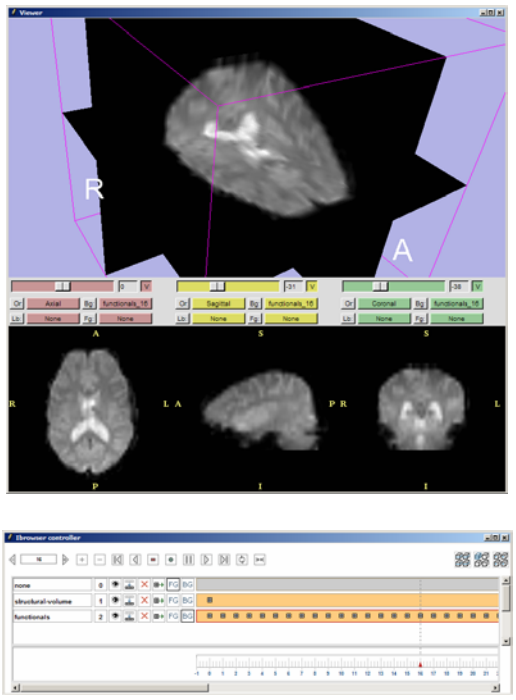

Figure 1: Interval Browser

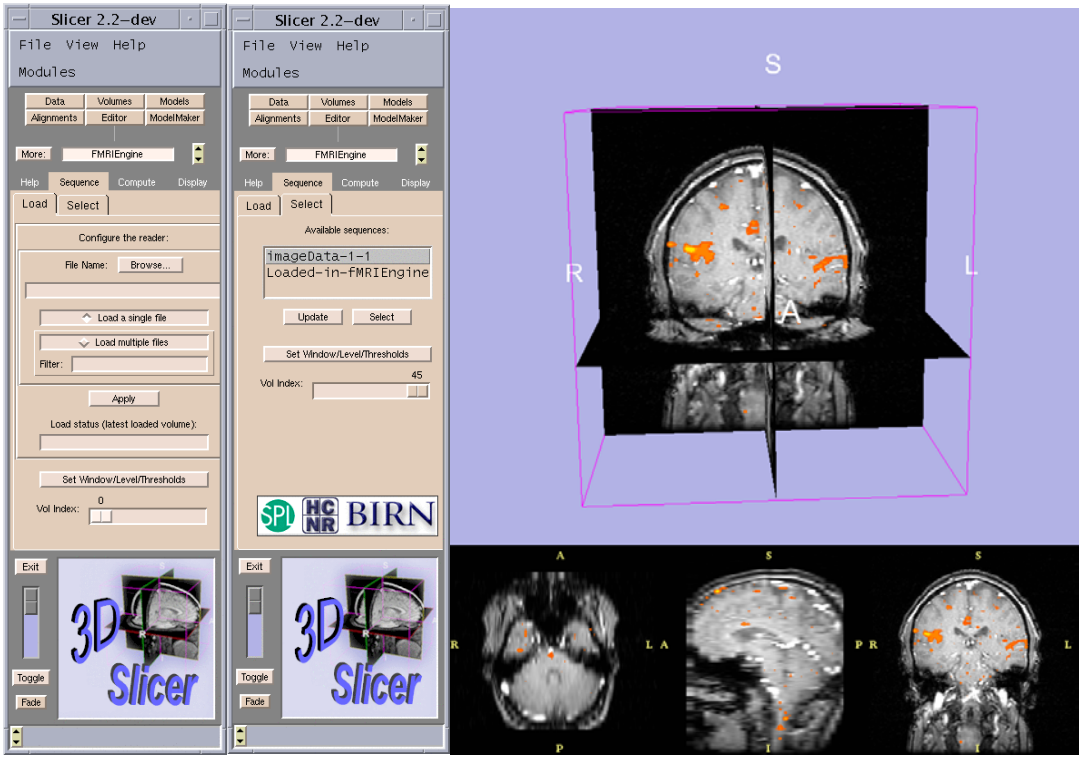

Figure 2: fMRI Engine GUI and Activation Visualization as Color-Coded Parametric Map of Activation

DTI Data Analysis in Slicer

In Slicer 2.4 capabilities for DTI data analysis have become available in the standard distribution.

This facility can be used to convert suitable collections of gradient images into volumetric tensor data. Subsequently, scalar statistics, including ADC and FA, can be derived from the tensor data. The tensor data can be visualized as glyphs, or Tractography features can be used to trace representations of tract structure from interactively located seed coordinates, or from specified regions of interest. Figure 3 shows a collection of tract tracings that were performed using Slicer's DTI tools.

Recently added features include:

1. Support for processing DTI acquisitions with more than 6 gradients
2. Rigid and non-rigid registration for DTI scans
3. Support for displaying High Angular Resolution diffusion images
4. Support for extracting "connectivity" between multiple ROIs
5. New algorithms for clustering fibers that connect similar regions
6. Support for new acquisition protocols and formats

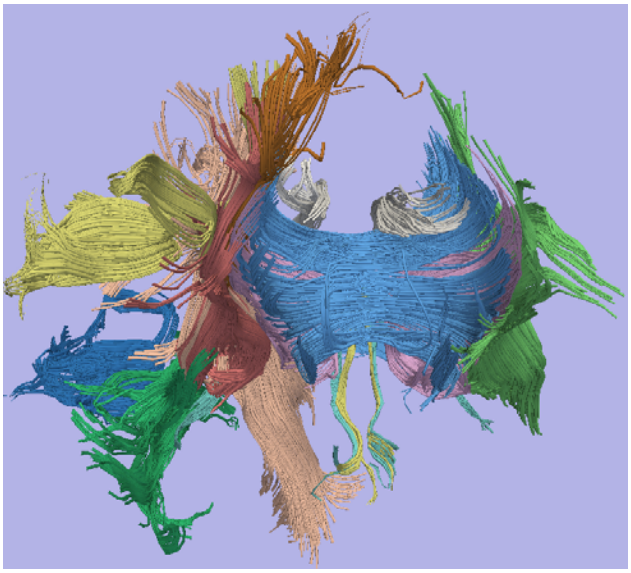

Figure 3: DTI Tract Tracings

Probe Tracking in Slicer

Slicer has facilities for acquiring the spatial coordinates of instruments intra-operatively. Until recently, in the MRT facility, this was done in conjunction with the optical tracking system that is part of MRT, and this has some drawbacks related to obscuration of tracked LEDs. We have recently begun trials with a new magnetic tracking system, EndoScout system, Robin Medical Inc. Baltimore MD USA, that is compatible with the MR environment. Being free of LED obscuration issues, this system is significantly easier to use in applications.

Surgical Case Example

The following example incorporates data from MRI, DTI, fMRI and intra-operative Electro Cortical stimulation that was performed with a tracked probe.

Figure 4 illustrates data from a neurosurgical case. 3D models of the tumor (green) and ventricles (blue) were derived from pre-operative MRI. Tracts were traced from pre-operative DTI. An fMRI activation from a speech paradigm is shown (orange), along with information from intraoperative Electro-Cortical stimulation. The purple model is an iso-surface of a current density that was solved on a patient-specific electrical conductivity model that was derived from DTI. The current density corresponds to a stimulation that resulted in speech arrest during the procedure. The corresponding locations of the electrical stimulator are shown as small blue spheres. The stimulation coordinates were recorded using a tracking device.

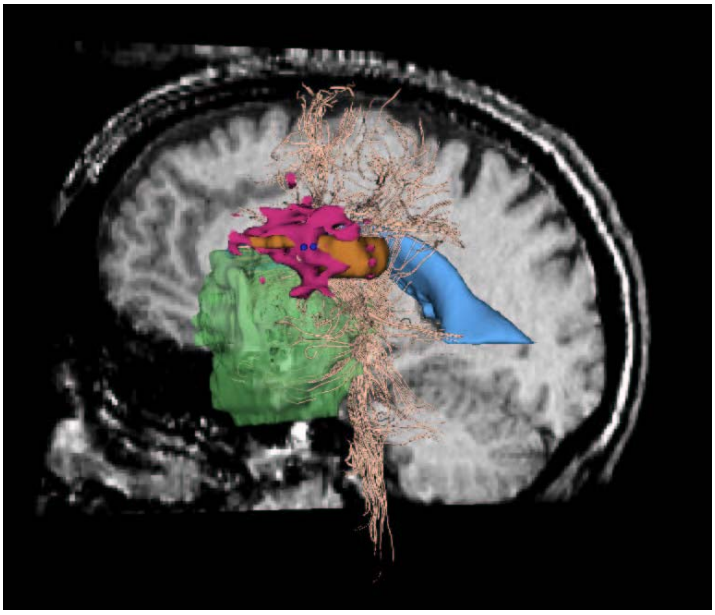

Figure 4: Visualization of Neurosurgical Case