Use of Remote Surface Based Tools for Visualizing Integrated Brain Imaging Data

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We describe a surface-based approach to 3D visualization of integrated neuroimaging data. Our web-enabled software allows researchers to use these visualization tools over the Internet. We present examples of brain imaging studies where such remote surface-based visualization techniques have proven to be quite effective.

Keywords: 3D visualization, neuroinformatics, brain imaging, web-enabled.

Brain imaging data acquired with MRI, PET and other modalities are usually represented as 3D image volumes, and are often analyzed and visualized as 2D slices. However, viewing brain imaging data as individual slices makes it difficult to relate the observations to the sulci and gyri of the cortical surface. We have developed surface-based visualization techniques that integrate the data from multiple modalities, and have implemented a web-based interface for these tools.

The system consists of a client-side Java applet and a graphics server. The server is implemented in Skandha4 – a general-purpose modular graphics toolkit that we developed (http://sig.biostr.washington.edu/projects/skandha4). We implemented several Skandha4 modules for processing MRI data: reconstructing 3D models of the cortical surface, veins and arteries; mapping functional data onto the 3D models; and importing and exporting MRI volumes, images and 3D models. The server capabilities of Skandha4 allowed us to implement client-server based web access to these modules. In this mode all computationally intensive tasks are done by the graphics server, which loads and processes image volumes and 3D models, renders 3D scenes, and sends the renderings back to the Java applet.

This system has been used in several neuroimaging studies. In an ongoing study by the University of Washington Human Brain Project, language mapping data are collected from patients undergoing neurosurgery for intractable epilepsy. Data from a single patient consist of MRI volumes showing anatomy, veins, arteries, and functional MRI, as well as the locations of electrically stimulated cortical areas. Surfaces of the cortex, veins and arteries are reconstructed from the MR data and used to map the cortical stimulation sites onto the brain, thereby allowing researchers to compare the effects of cortical stimulation and fMRI for language localization (Figure 1).

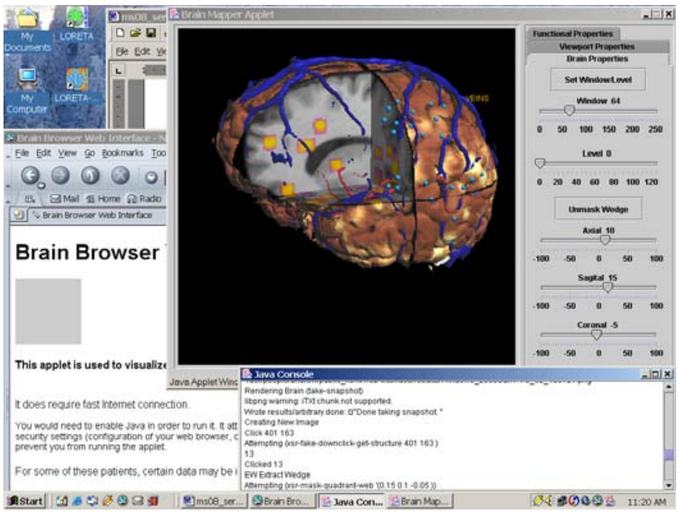

Figure 1. Screen shot of the Brain Visualization client

In a different study on autism, researchers used the tools to compare several functional modalities, including fMRI, spectroscopy (PEPSI) and electromagnetic tomography (EEG/ERP source analysis). In yet another study, repetitive transcranial magnetic stimulation (rTMS) is being used as an experimental, less traumatic alternative to ECT ("shock therapy") in the treatment of drug-resistant depression. Although stimulation of the left prefrontal cortex has been shown to have antidepressant effects, the exact location of the "sweet spot" for stimulation is unknown. We have reconstructed the cortical surface and coil location in several TMS patients, and are correlating the exact locus of stimulation with the clinical response to rTMS. Visualizing these results allows researchers to pinpoint which cortical areas were stimulated, and should ultimately lead to a refinement of the TMS technique.

In all these studies the ability to remotely view complex 3D visualizations on a standard web browser has been very productive. We have therefore begun developing next-generation remote 3D visualization tools that should be portable across many environments (see companion poster by Moore et al). We will discuss the possible scope of application of such tools, which range from collaboration of several labs to integration into large-scale repositories of neuroimaging data (e.g. fMRI Data Center, http://www.fMRIDC.org).

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