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

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Abstract

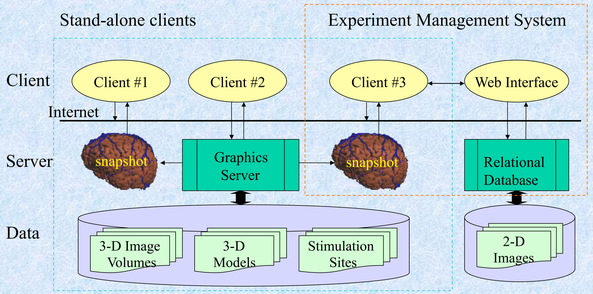
We describe a surface-based approach to 3-D visualization of integrated neuroimaging data. Our web-enabled software allows researchers to use these visualization tools over the Internet. We present examples of brain imaging studies where such remote surface-based visualization techniques have proven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

System Description

The system consists of client-side Java applets or CGI web pages, and a Graphics Server (Fig 1). The server is implemented in Skandha4, a general-purpose modular in-house graphics toolkit whose design facilitates client-server based web access. In client-server mode all computationally intensive tasks are done by the Graphics Server, which loads and processes image volumes and 3-D models, renders 3-D scenes, and sends the renderings back to the client. Clients are either stand-alone web-based 3-D visualization tools (Clients 1,2), or integral parts of an Experiment Management System (EMS) for language mapping data (Client 3) The EMS allows users to store numeric and text-based data (e.g. patient demographics, transcripts of experimental trials, etc.) in a relational database, and to edit and manage these data on the web[1]. The EMS is also used to organize 2-D images (intra-operative photographs etc.).

The upper left window of Fig 2 is a screenshot of the EMS Web interface, with links to a photograph (lower left), an individual set of trials (lower right) and the visualization applet (upper right, client 3 in Fig 1).

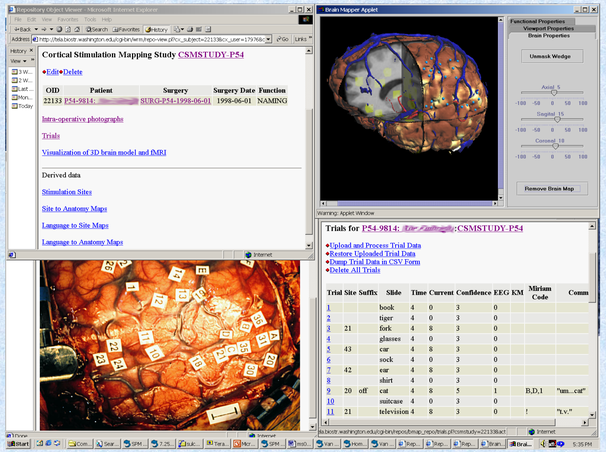
Figure 1 System Architecture



Case 1 Pre-surgical visualization of fMRI data on the reconstructed cortex surfaces

In an ongoing study, language mapping data are collected from patients undergoing neurosurgery for intractable epilepsy[2]. Structural and functional MRI data are acquired prior to surgery. During the surgery, cortical stimulation mapping is performed and single neuron activity may be recorded from areas that will be resected. Reconstructions of 3-D models and fMRI analysis are performed prior to surgery, and the neurosurgeon accesses a visualization of this integrated data on the web before or during the surgery. In particular, the visualizations help planning experimental recording of single neuron activity in the areas that were found to be active during language tasks, as revealed by fMRI.

Figure 2 Experiment Management System and, in upper right, visualization applet showing data for case 1



Case 2 TMS localization on cortex models

Another group of researchers is evaluating rTMS (repetitive Transcranial Magnetic Stimulation) as an experimental treatment technique for resistant depression, a less traumatic alternative to ECT ("shock therapy"). 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. Using our tools, researchers are able to localize the position of the coil (yellow in Fig 3) with respect to the individual patient's cortex model and show it's projection on the cortex surface (blue).

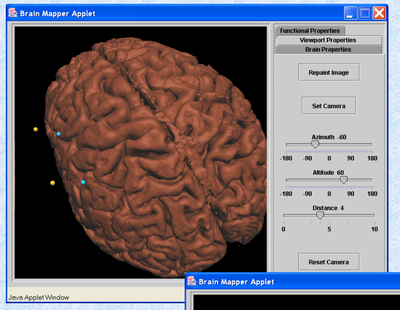


Figure 3 TMS data

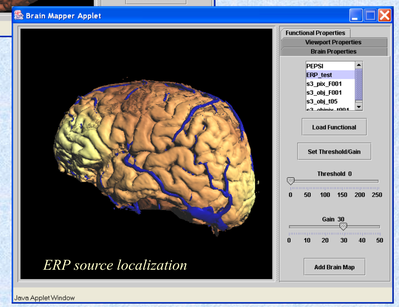


Figure 4 Multimodality data

Case 3 Integrating functional data from multiple modalities

In a study of Autistic patients, researchers are collecting functional data from multiple modalities (Fig 4), including:

- Electromagnetic tomography (EEG/ERP source localization)
- Functional MRI
- Proton Echo-Planar Spectroscopic Imaging (PEPSI)

Future Work

- Visualization of additional modalities
- Visualization of time-varying modalities
- Interoperability with popular neuroimaging software, including support for file formats and data structures

Generalization to other applications

- Teleradiology
- Treatment planning
- Experiment management
- Online medical record

Conclusions

3-D visualization of cortical and other surfaces is critical for analyzing certain types of neuroimaging data, since volume based visualization techniques cannot reveal the relation to cortical anatomy[3] (sulcal and gyral patterns in individual subjects).

The client-server approach makes it possible to interactively view and analyze 3-D scenes using just a standard web browser, and eliminates the need to install and maintain 3-D hardware and software or store massive amounts of neuroimaging data on the user workstation.

We have therefore begun developing next-generation remote 3-D visualization tools that should be portable across many environments (see companion poster by Moore et al).

Acknowledgements

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References

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