Brain Visualization in Java3D

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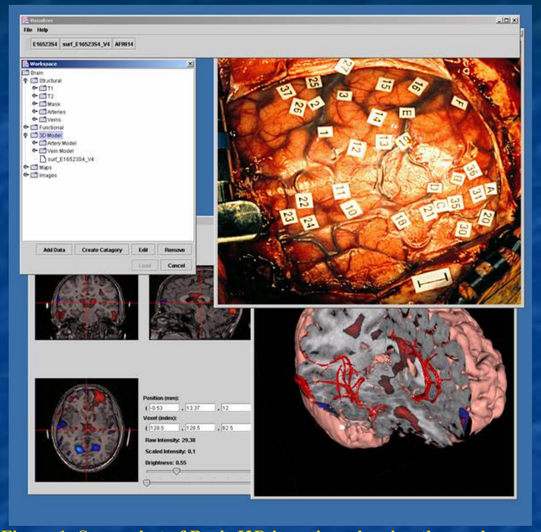

Figure 1: Screenshot of BrainJ3D in action, showing the workspace, an intra-operative photo, the MRI viewer with fMRI, and the 3D surface model with the same fMRI.

Introduction:

BrainJ3D is designed to meet the needs of current and future users wanting to visualize and share 3-D neuroimaging data. Unlike many neuroimaging applications, which run only on Unix, BrainJ3D runs on both Unix and Windows. Users also require fast performance, and should not be expected to convert their data into new formats. Furthermore, neuroscientists have an increasing need to collaborate and share data - with the world and with a trusted group of people. BrainJ3D facilitates the possibility of secure sharing.

BrainJ3D has 2 main modes: client/server and standalone. Each uses the same interface and supports the same data types. Both work with a variety of data, including structural MRI volumes, functional volumes (fMRI, ERP, etc.), 3D surfaces (cortex, veins, arteries, etc.), surgical photographs, and maps. Standalone mode is designed for speed, portability, and interoperability. It is hardware accelerated, and uses data from common analysis packages like SPM, AFNI or FSL. All of these design characteristics make standalone mode accessible and usable by the widest possible audience. Conversely, client/server mode aides collaboration by allowing users to share neuroimaging data over the web with a fine level of control over data access.

Visualization

- Slice viewer:
  - Overlay of functional volumes onto structural data
  - An arbitrary number of volumes can be overlaid.
- 3D surface:
  - Extracts surfaces from masked volumes.
  - fMRI can be projected to the cortical surface.
  - Multiple models can be displayed at once (Cortex, Veins, Arteries)
  - Cutaway view allows the user to see inside the brain.
  - The user can overlay fMRI data onto the cutaway view.

Mapping

- Map points using pick operation or arbitrary locations in space.
- Assign any text or number label to a point.
- Display label text and/or a choice of shapes.
- Nodes can be arbitrarily grouped.
- Each group has its own appearance.

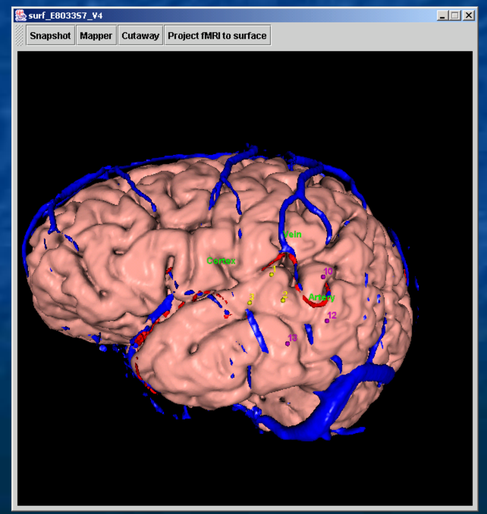

Figure 3: 3D cortical surface with vein, arteries and labels.

Workspace

- Organizes and manages patient data.
  - The user only needs to find the data once.
  - The program can use the workspace to automatically load appropriate data
- Stored in XML format, so it is easily customizable.

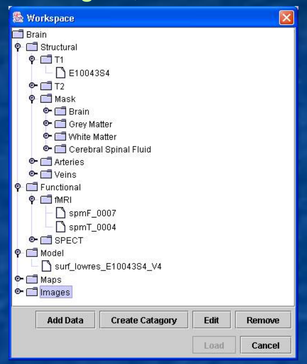

Figure 4: The workspace organizes information so that the user and the program can find required data easily.

Client/Server Mode

Client/Server mode consists of several pieces. The client application is a thin client that can be downloaded over the Internet using Java WebStart, allowing Java applications to be downloaded and updated automatically. The server side consists of both a webpage that serves the client over WebStart and the BrainJ3D server that processes the neuroimaging data.

Because we use a thin client, no data are sent over the Internet; only the GUI and snapshots of the current view are sent. Because the client does not perform any rendering, the user does not need a 3D graphics card or Java3D installed to run the program.

After downloading the WebStart application (1), the user must login (2) and if successful, a customized set of permissions are granted to that user (4). After logging in, the user may send commands to the server to load data or change the view (5). The server will then load any file (6) according to the user's privileges and send back the current view of the data as a snapshot with controls (7). The user may send as many commands as desired, and the program will repeat the security process described above for access to new data. Repetitions of the security loop beyond the initial login are transparent to the user and will run automatically through the program.

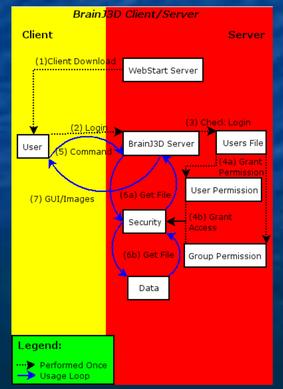

Figure 5:Client/Server in action.

Security

- Designed so that each user has an individual set of Java privileges
  - File privileges are enforced by the Java Security Model (using AccessControlContext's).
  - Different users have different access levels, including:
    - Individual controls over access privileges (read, write).
    - Individual views of the file system.
  - Groups also exist to grant several users the same access and views of the files.

Architecture

The system consists of 2 parts: the thin client and the server. The thin client (red) only presents and displays the GUI and communicates with the server. The server (yellow) has modular tools that encompass the program's functionality and manage the data. Specialized GUI components (orange box) synchronize and communicate between the client and the server.

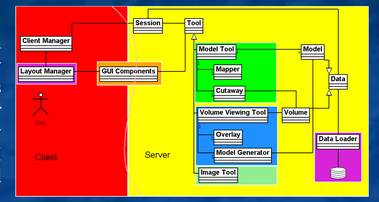

Figure 6: Architecture Diagram

The client side remains simple because it mainly presents and tracks the active GUI components. The layout engine (left purple box) is customizable so that users may work with individual layouts, such as the current interface with several windows, or a single tabbed window.

The server consists of several modular tools (green and blue boxes) to display and manipulate data. These can be extended further with sub-tools to provide extra functionality. The modular design enables new functionality to be easily added or to be left out in order to provide a custom server. Also, the server can be extended to load data from sources other than a hard drive by writing custom data loaders (right purple box)..

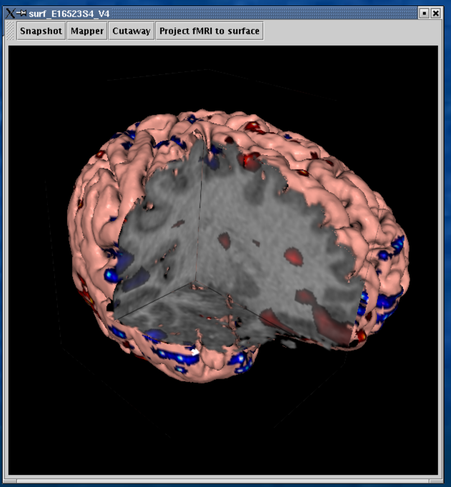

Figure 7: 3D cortical surface with cutaway and fMRI.

Conclusion

BrainJ3D is fast, portable and integrates well with other applications. It runs on both Windows and Linux, and is designed to be easily expandable to keep up with changing usage and technology. Aiding and abetting collaboration is key to BrainJ3D as partnerships are likely to increase in importance among neuroscientists.