Java Internet Viewer: a WWW Tool for Remote 3D Medical Image Data Visualization and Comparison

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Introduction:

There is a growing need in the research and clinical medical imaging community for Internet-capable tools that facilitate remote data dissemination and interaction. 3-dimensional (3D) medical imaging datasets typically require special-purpose, non-portable, software to be installed and maintained on each workstation.

We developed "JIV": a powerful, robust, portable, extensible, and open-source Java (v 1.1) application (applet) for visualization and side-by-side comparison of multiple 3D image datasets. JIV is designed to work through the WWW.

A convenient way to visualize 3D medical imaging datasets is by three orthogonal 2D slices through the same location in the volume. When several image volumes are to be compared, it is desirable to visualize their slices side-by-side, all at the same position in the volume (fig. 1).

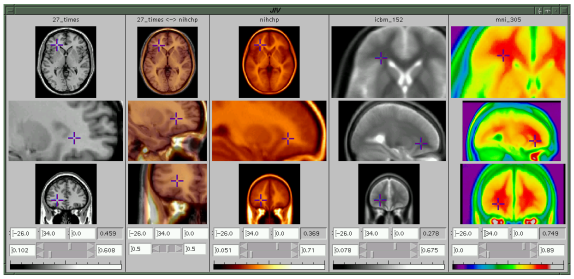

Figure 1: Screenshot of the JIV interface: four datasets are displayed, each with the three orthogonal 2D slices (top to bottom: transverse, sagittal, coronal). A merged image of the first two datasets is also displayed (2^{nd} column from the left). Some of the slices are zoomed-in, by different amounts.

JIV Features:

- requires no installation and no maintenance on the workstation, but only a common Web browser.
- highly portable: the vast majority of computers come with Web browsers, which support Java 1.1. JIV proved to be robust on a variety of computer platforms: Linux-i386, SGI IRIX, MacOS, and various MS Windows (Win32) versions.
- can cope with slow network links.
- uses a simple and platform-independent image data format, and accepts arbitrary volume samplings.
- displays gray-level (intensity) image data with a user-controlled color-mapping; also provides merged (blended) views of two datasets.
- an efficient mouse-based user input scheme provides fast roaming through the volume, and continuously adjustable zoom and pan.

Design & implementation:

In order to provide remote data access with a level of performance comparable to traditional stand-alone workstation applications, the issue of file loading ("I/O"), which is significantly slower, needs to be addressed. In practice, the performance of regular Internet connections is unpredictable; moreover, the transfer rate can vary by up to three orders of magnitude (1000x) among different types of network connections. With respect to how and when to download the 3D image data, the following three operation modes are supported by JIV:

1. *All up-front:* all of the data is downloaded and stored in client's memory before the user can view and interact with any of it. This guarantees the best interactive response of the viewer; however, the user has to wait for all the data to download before the JIV interface becomes available, which can be impractical.
2. *On demand:* download slice image data only when and if the user wants to view that particular slice. This minimizes the data downloads (and the amount of memory required by the applet), but the interactive response time is highly dependent on the server and on the network speed.
3. *Hybrid (background download):* first download only the slices required by the initial cursor positions; then continue downloading all of the data in a background thread (as in (1)); if the user requests slice images which are not already downloaded, they will be downloaded with priority (as in (2)).

The hybrid mode (see fig. 2) is the best compromise for most practical situations, and can be seen as a *predictive* download approach. JIV could be configured to first transfer the slices with high probability of being visited by the user (this probability is application and data dependent); such a technique will increase the likelihood of the image data to be already available when the user moves the cursor to a new location.

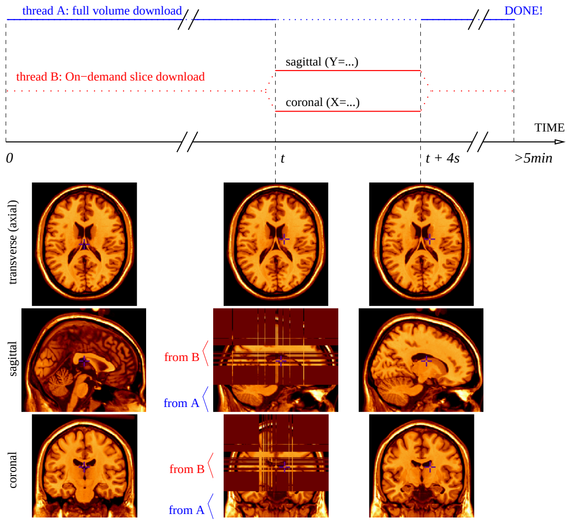

Figure 2: The hybrid download functionality: thread A performs the background download of the entire 3D image volume (takes >5min); thread B downloads, with priority, the 2D slices required by the current cursor position. Above, the user moved the cursor to a new location at time *t*. JIV does not temporarily freeze while waiting for data to arrive: instead, it displays a discernible pattern for the image areas it does not yet have (time *t*), and replaces it with the real image data as soon as it becomes available (time *t+4s*). Any 2D slice is only downloaded once. The download times shown above correspond to a 14 Kbyte/sec network connection (typical ISDN line) and to a T1-weighted / 181x217x181 / 1 mm^3 isotropic sampling brain MRI, compressed with `gnuzip` (lossless compression).

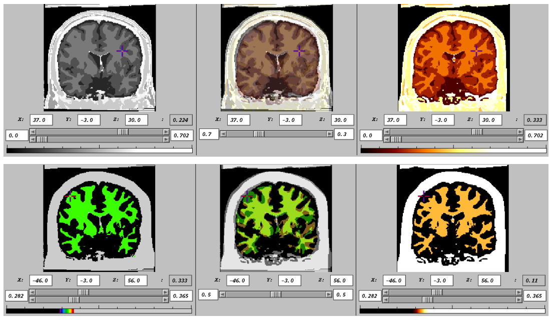

Figure 3: Sample JIV application: evaluating the mis-registration of two brain MRI-s, after tissue classification. Bottom: the colormap range sliders (window/level) can be used to restrict the visible tissue classes.

Results & Conclusion:

An online demo as well as the software are available at the Web address in the title.

JIV is a convenient and platform-independent software for the remote visualization of 3D medical image data; for example, it can be used in remote data processing – when data goes to a central, well-equipped, site for image processing and storage. This software proved useful (both remotely, as an applet, and as a stand-alone application) for efficient simultaneous visualization and comparison of many 3D image datasets, such as evaluating the performance of registration or segmentation methods (fig. 3). It can also be used as a PACS viewer in a radiology environment.

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