Visualizing Diffusion Tensor Imaging Data with Stereoscopic Vision

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Introduction: As a technique that enables quantitative measurement of molecular diffusion in biologic tissues in vivo, diffusion tensor imaging (DTI) has many clinical applications, such as mapping the 3D pathway of white matter (WM) fiber, delineating tumor infiltration, assessing the integrity of neuronal fibers, surgical planning, and so on. However, displaying and visualizing DTI data is more complicated, and many schemes have been proposed before. We propose an alternative technique and the software/hardware tool that uses stereoscopic principles to give a more natural and intuitive visualization of DTI data.

Materials and Methods: By creating the stereoscopic image pair (i.e., the left-eye-view and the right-eye-view image) of the principal eigenvector ($\mathbf{V}_{max}$) and the fiber tracts and by using a stereoscopic display device, a human viewer will get the natural, true 3D perceptions of the relative depth and directional information of the $\mathbf{V}_{max}$ and the tracts. The visualization tool was developed in Microsoft C^{++}. Stereovision is achieved using a glasses-free stereoscopic monitor by projecting the left-eye and right-eye view interlaced as the even and odd vertical lines on the screen. At a certain viewing distance, the right-eye view is visible only to the right eye and the left-eye view only to the left eye, creating the natural 3D perceptions of the eigenvector's orientation and the fiber tracts' geometric and spatial information without the use of polarizing glasses.

This tool has two functions: 1) displaying the 3D field of the $\mathbf{V}_{max}$ at all pixels on three orthogonal planes that can be moved along their axes. The $\mathbf{V}_{max}$ at each voxel is represented as colored headless 3D arrows with both the relative length of the lines and their color corresponding to the anisotropy. 2) fiber tracking. The tractography function generates stereoscopic views of the WM tracts with colors along the tracts corresponding to the anisotropic index, fractional anisotropy (FA) values.

Results: Stereovision is achieved with the glasses-free monitor. The tool can also generate stereo image pairs and present them on paper (Figure 1). Compared with the method of using color to encode the tensor's directional information as is often done today, stereo-viewing provides a more intuitive and natural representation of the fiber tracts' geometric and spatial information while enabling the use of color for anisotropic properties along the tracts.

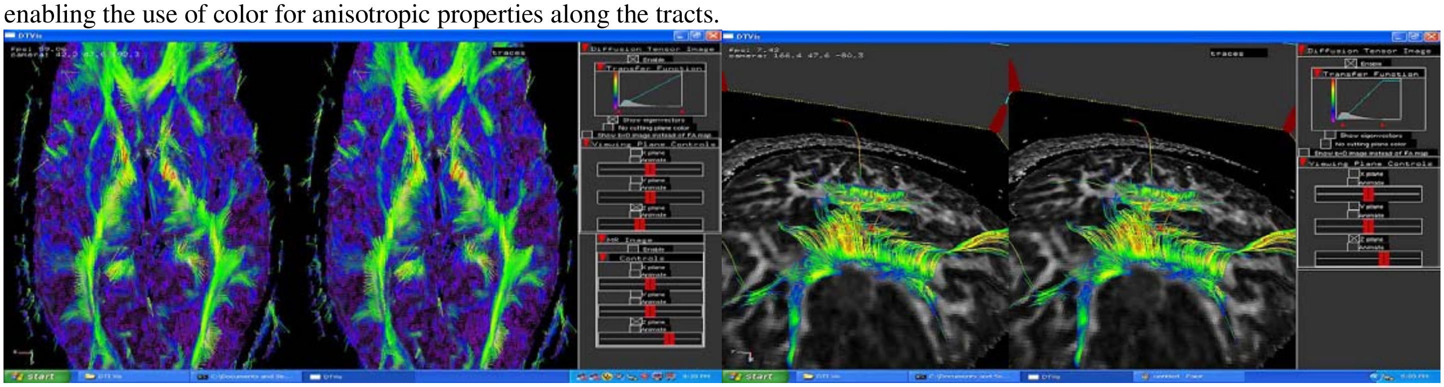

Figure 1. Screen shot of the DTI visualization tool. Left panel is $\mathbf{V}_{max}$ represented as arrows on an axial plane. Color represents the anisotropic index (FA) value. Notice the vivid spatial separation of the WM fiber tracts in stereo mode (two images on the right panel) vs. a pseudo-3D static image (any one of the two right panel images).

Discussion and Conclusions: Because of DTI's great potential in clinical applications, it is important to present DTI data in an intuitive, user-friendly way. Using stereoscopic vision may provide such an alternative to the color-coding methods used today. One of the advantages of using stereo vision is that it automatically gives a natural and intuitive perception of the depth, relative locations, and orientation of WM fiber tracts, without the use of any reference color palette, while enabling the use of colors to represent other important DTI parameters such as anisotropic index values or the diffusivity values along the tracts simultaneously. Another advantage is that one can create the stereo image pair and achieve the 3D perception and spatial separation of fibers on paper (thus easier for journal publication) or on a computer monitor without any special software tool, thus making DTI visualization portable in the clinical setting. From the stereo image pair, the stereo vision effect can be easily achieved by presenting the pair of left- and right-eye views side by side. One can then simply place a divider (e.g., a piece of cardboard or a book) in the middle of the left and right images, put his or her nose against the divider, and look at the images. With a little practice, people with normal stereo vision can achieve the stereo effect easily.

Stereoscopic viewing of medical images may find unique use in some clinical applications. It can be achieved on a stereo monitor or on paper with the stereo image pairs thus easily portable.

References: 1). Pajevic S and Pierpaoli C, MRM, 42:526-540 (1999). 2). Peled S et al, Brain Res. 780(1):27-33 (1998).