Visualization of the interaction of multiple sclerosis lesions with adjacent white matter fibers using streamtubes and streamsurfaces

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1 Introduction

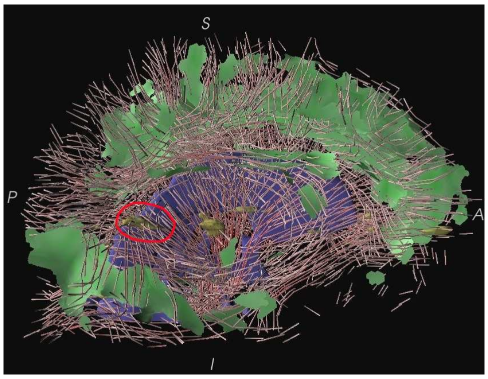

Fig. 1. Whole-brain visualization of a diffusion imaging dataset from a multiple sclerosis (MS) patient. The visualization shows the lesion mask in semi-transparent yellow surfaces along with the streamtubes model, the streamsurfaces model, and the ventricles. The lesion mask was collected in a separate acquisition, segmented manually, and registered with the DTI data set. The circled region is detailed in Fig. 2.

We visualize diffusion tensor imaging (DTI) data together with structural MRI data; both datasets were acquired using 3T MRI from a multiple sclerosis (MS) patient with early disease and a low lesion load. Visualization of the DTI data includes red streamtubes representing regions of linear diffusion anisotropy, green streamsurfaces representing regions of planar anisotropy, and blue cerebrospinal fluid regions for anatomical context [1]. Focal MS lesions from the structural MRI are represented as yellow surfaces.

2 Results and Discussion

Fig. 1 shows a whole-brain visualization, providing context for multiple sclerosis (MS) lesions within the complex connectivity of human white matter. We have displayed this visual representation in several interactive environments, including a standard desktop and a fishtank virtual reality (VR) display environment. Stereo display in the VR environment is extremely helpful for determining the 3D structural relationships between lesions and white matter structures.

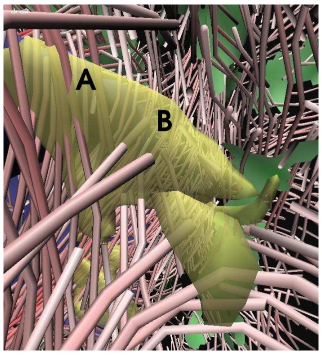

Fig. 2. A close look at the white matter fibers near the MS lesions. The streamtubes around the lesion area give some clues about white matter structural changes near the lesion. Note that the streamtubes sometimes continue through the lesions (A) and sometimes break within them (B).

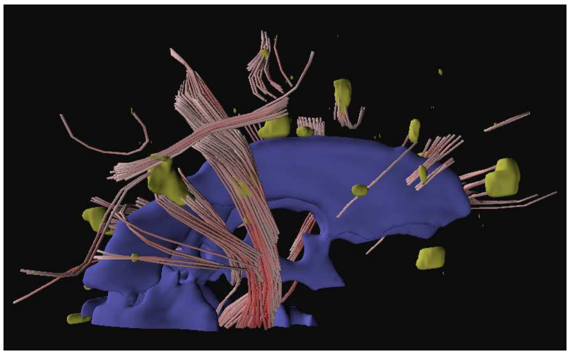

Fig. 3. The same brain and view as Fig. 1, but showing only streamtubes that contact the lesions. This visualization makes clear the involved white matter structures.

The circled region of Fig. 1 is enlarged in Fig. 2. From this figure, it can be seen that streamtubes sometimes pass through these lesions and sometimes break within them. Both behaviors are consistent with demyelinating lesions. A third possible behavior, which we do not observe here would be for lesions to displace white matter fibers away. We hypothesize that the latter behavior would be more consistent with neoplasm or rare tumefactive MS lesions, and our visualization method may help distinguish neoplasm from MS lesion, a task that is at times difficult by conventional MR imaging

Fig. 3 shows lesions, ventricle, and only the subset of streamtubes that contact the surface of the MS lesions. This view provides perspective that can be utilized to determine the relationship between focal lesions and the neuronal tracts that are anatomically related. From this visualization it is possible to determine which specific fibers are involved, their direction and potential functional significance, all of which is difficult or impossible with conventional 2D or 3D imaging.

3 Discussion and Conclusion

The visualization approach we describe has begun to help elucidate where lesions are in the 3D context of the human brain and how extensive they involve white matter structures. There is no other non-invasive method for making these observations. These results suggest that such visualization methods may be valuable to observe progression of MS over time, to improve our understanding of the underlying pathophysiology and assist in differential diagnosis.

4 Reference

[1] Zhang et al. IEEE TVCG. 9:454-462(2003)