Visualization and Analysis of Diffusion Tensor Fields

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Abstract

The power of medical imaging modalities to measure and characterize biological tissue is amplified by visualization and analysis methods that help researchers to see and understand the structures within their data. Diffusion tensor magnetic resonance imaging can measure microstructural properties of biological tissue, such as the coherent linear organization of white matter of the central nervous system, or the fibrous texture of muscle tissue. This dissertation describes new methods for visualizing and analyzing the salient structure of diffusion tensor datasets. Glyphs from superquadric surfaces and textures from reaction-diffusion systems facilitate inspection of data properties and trends. Fiber tractography based on vector-tensor multiplication allows major white matter pathways to be visualized. The generalization of direct volume rendering to tensor data allows large-scale structures to be shaded and rendered. Finally, a mathematical framework for analyzing the derivatives of tensor values, in terms of shape and orientation change, enables analytical shading in volume renderings, and a method of feature detection important for feature-preserving filtering of tensor fields. Together, the combination of methods enhances the ability of diffusion tensor imaging to provide insight into the local and global structure of biological tissue.