

Tensorlines: Advection-Diffusion based Propagation through Diffusion Tensor Fields

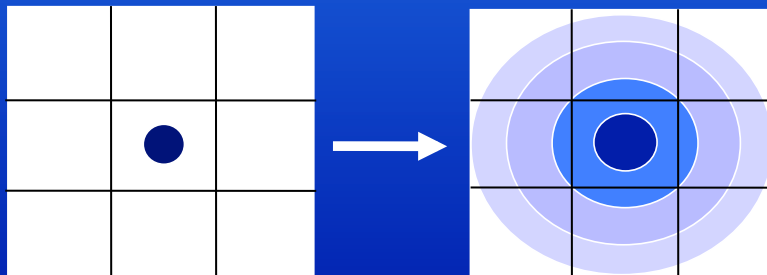
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Eric Lundberg

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University of Utah

Diffusion Tensor MRI

Tensorlines

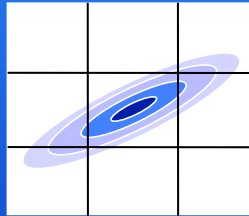
- Imaging modalities - physical properties
- MRI parameters
 - Different tissues
 - Temporal sequence - fluid flow
- Diffusion from multiple flow measurements



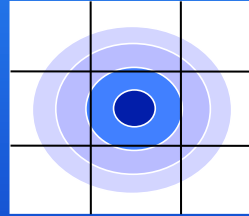
Motivation

Tensorlines

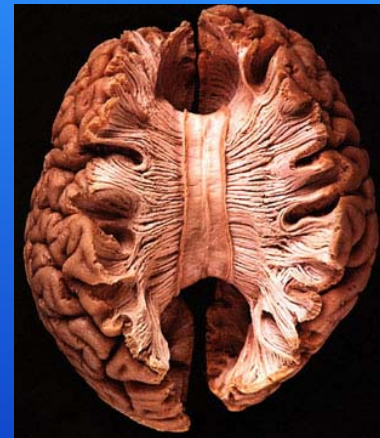
- Track pathways in the brain
- Axons diffuse anisotropically



White Matter



Other Tissue

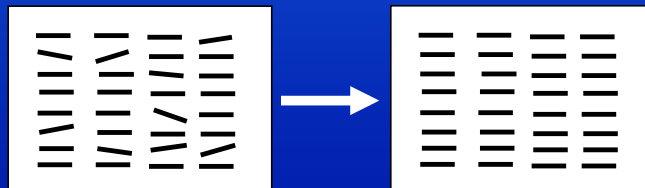
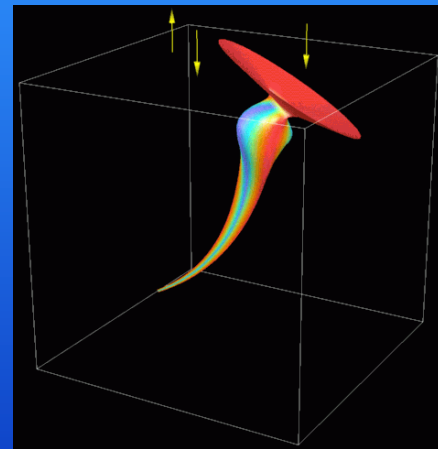


- Feature tracking
 - Linear: use vector field advection in major axis direction (streamlines)
 - Non-linear: ??

Previous Work

Tensorlines

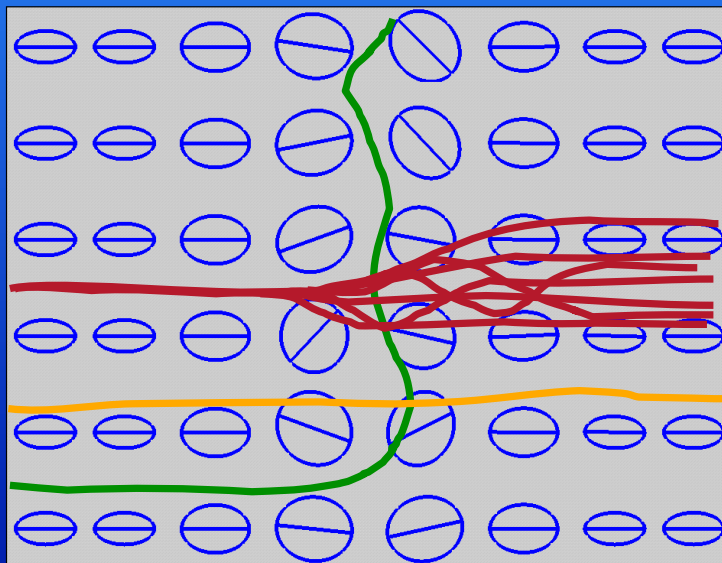
- Stream polygons (Schroeder `91)
- Hyperstreamlines (Delmarcelle `92)
- Precomputed connectivity (Conturo `99)
- Regularization (Poupon `98)



Main Observation

Tensorlines

- In voxels that do *not* have linear anisotropy, the major axis direction does *not* necessarily mean much.



Anisotropy (tensor “shape”)

Tensorlines

- Eigenvectors

$$D = R \Lambda R^T$$

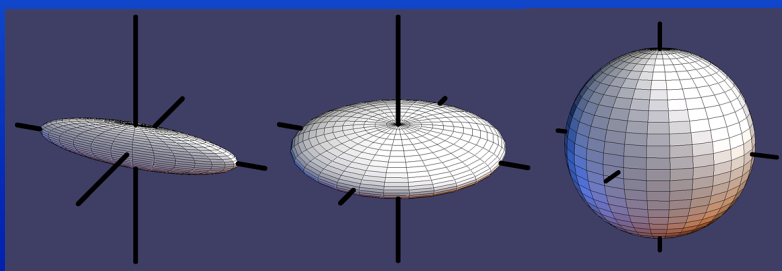
$$\begin{bmatrix} 0.9 & 0.1 \\ 0.1 & 1.0 \end{bmatrix} = \begin{bmatrix} 0.53 & 0.85 \\ 0.85 & -0.53 \end{bmatrix} \begin{bmatrix} 1.06 & 0 \\ 0 & 0.84 \end{bmatrix} \begin{bmatrix} 0.53 & 0.85 \\ 0.85 & -0.53 \end{bmatrix}$$

$$\begin{bmatrix} 0.9 & 0.1 \\ 0.1 & 1.0 \end{bmatrix} = R \Lambda = E$$

$$= \begin{bmatrix} 0.56 & 0.71 \\ 0.90 & -0.44 \end{bmatrix}$$

- Types

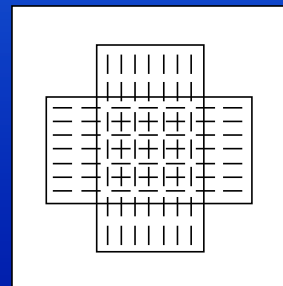
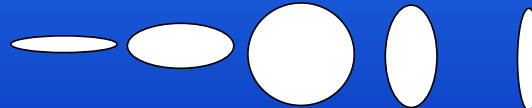
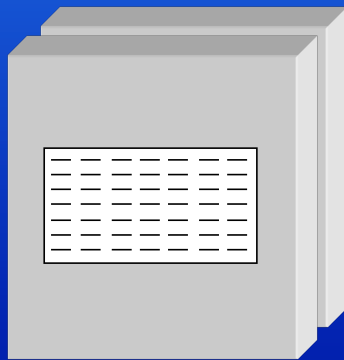
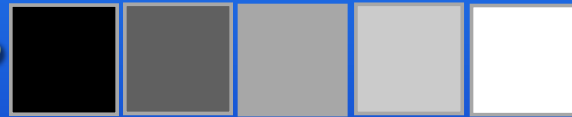
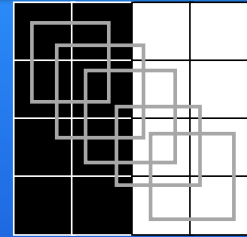
- Linear
- Planar
- Spherical



Partial Voluming

Tensorlines

- Synthetic dataset
 - Two bricks of linear anisotropy
 - Sampled at different resolutions
 - Partial voluming ratio

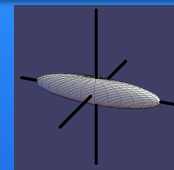
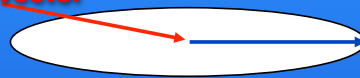


Output Direction Heuristics

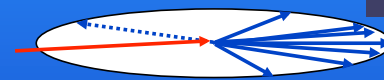
Tensorlines

- Linear
 - Major axis direction
 - Probabilistic direction

Input Vector

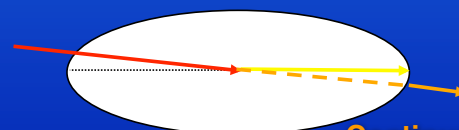
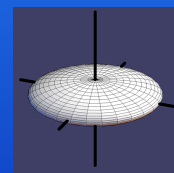
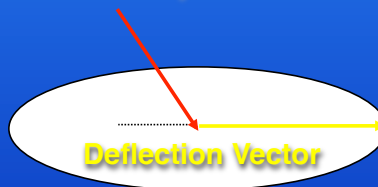


- Probabilistic direction



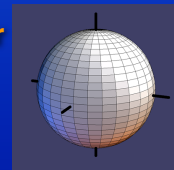
Major Axis / Diffusion Vector

- Planar
 - Out of plane
 - In plane



Continuation Vector

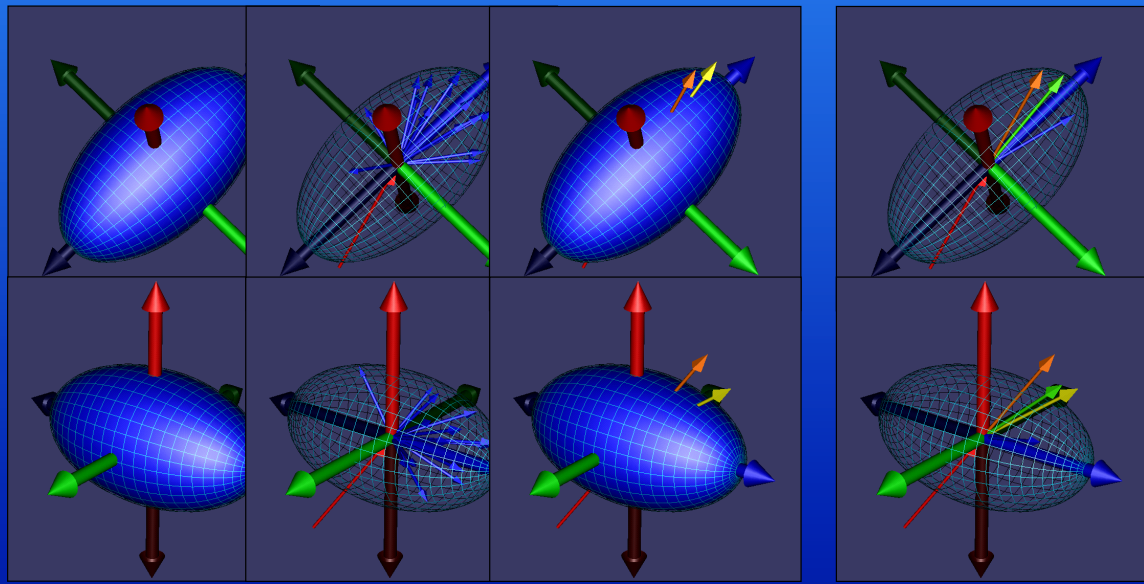
- Spherical
 - Keep going in the same direction



Putting It All Together

Tensorlines

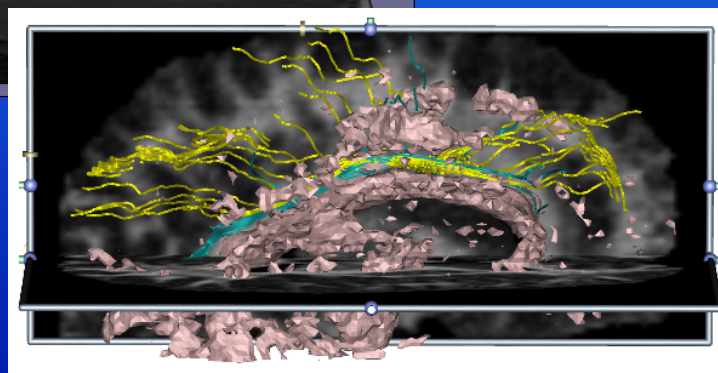
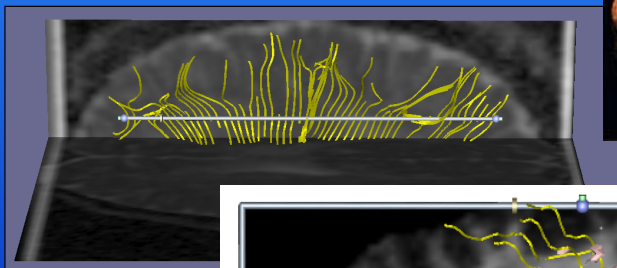
- Advection - Diffusion
- Weighted sum



Results

Tensorlines

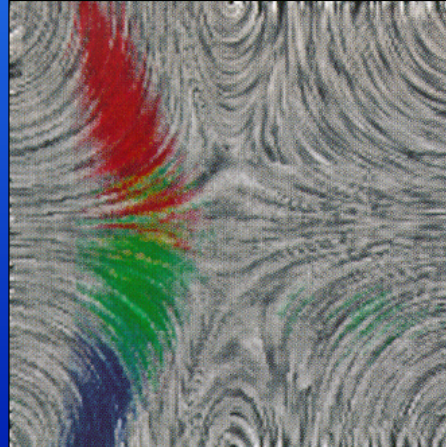
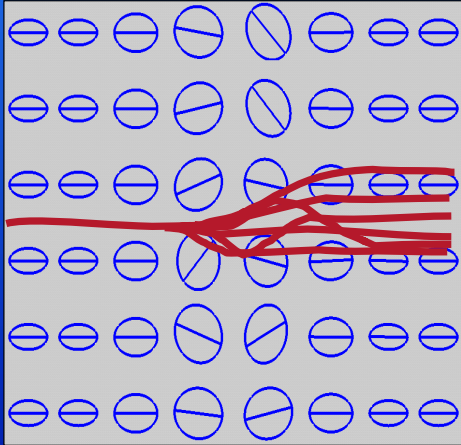
- Planar white matter
 - Corona radiata



Current Research

Tensorlines

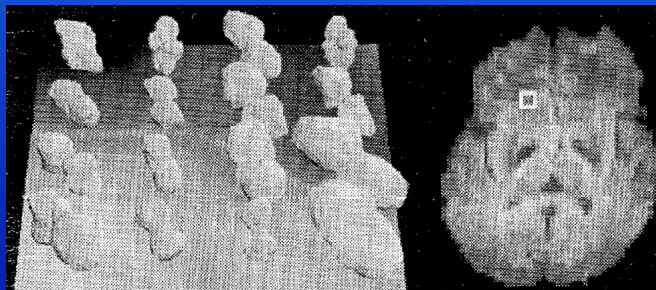
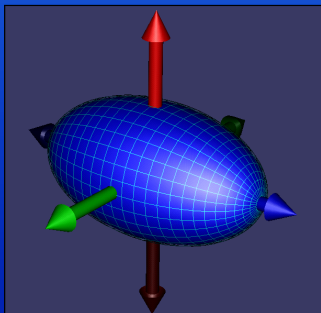
- Diffusion-based flood-fill
 - Inject dye stream (*ala* LIC)
 - Probable diffusion over time



Open Research Questions

Tensorlines

- Track other features
 - Vessels
 - Tumors
- Integrate non-ellipsoidal direction distribution function



- **University of Utah**
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 - Center for Scientific Computing and Imaging
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 - Department of Energy (DOE)
- **Data**
 - Center for Advanced Medical Technologies (CAMT)