Visualization of Anatomic Covariance Tensor Fields

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Background

Anatomic Variability: expected amount and type of structural variation between individuals
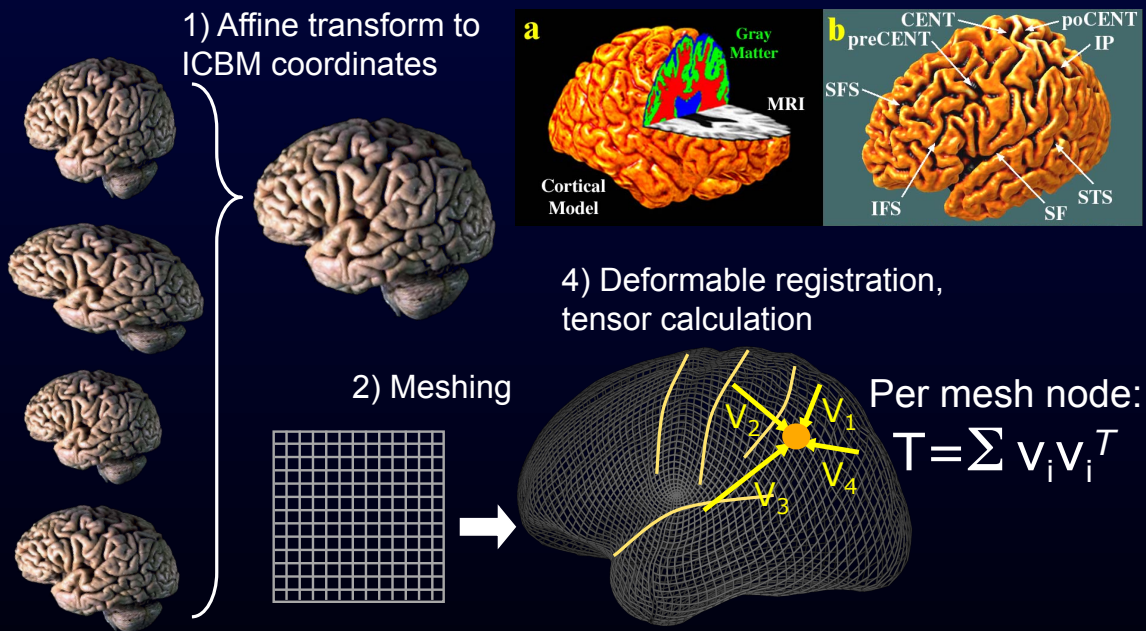
In human brain:

• Functional imaging

• Characterize disease-specific variations

• Assist feature recognition algorithms

Generated by deformable registration methods

Visualized by glyphs previously used in diffusion tensor visualization

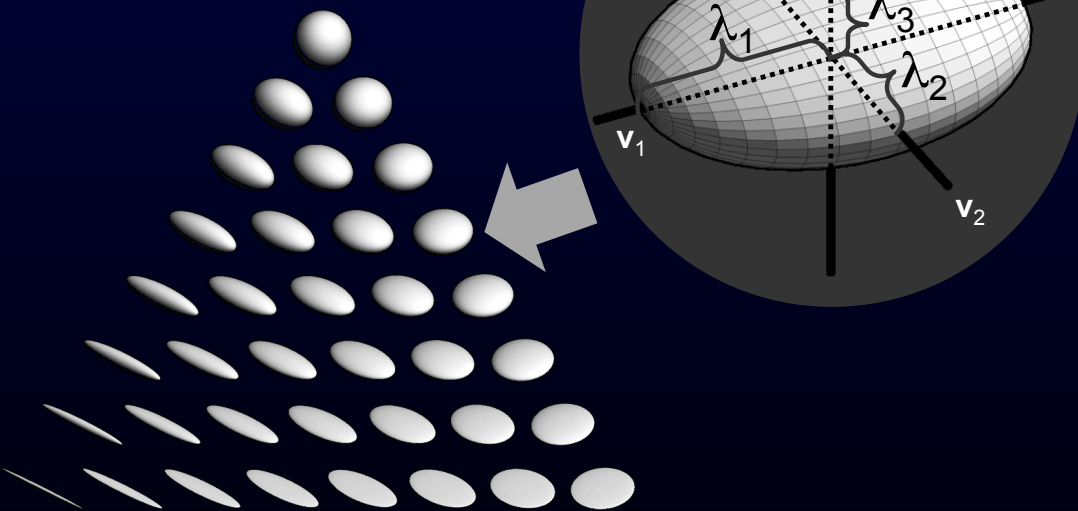# Tensor computation

Mazziotta et al., 2001

1) Affine transform to ICBM coordinates

2) Meshing

3) Cortical surface extraction, definition of sulcal landmarks

4) Deformable registration, tensor calculation
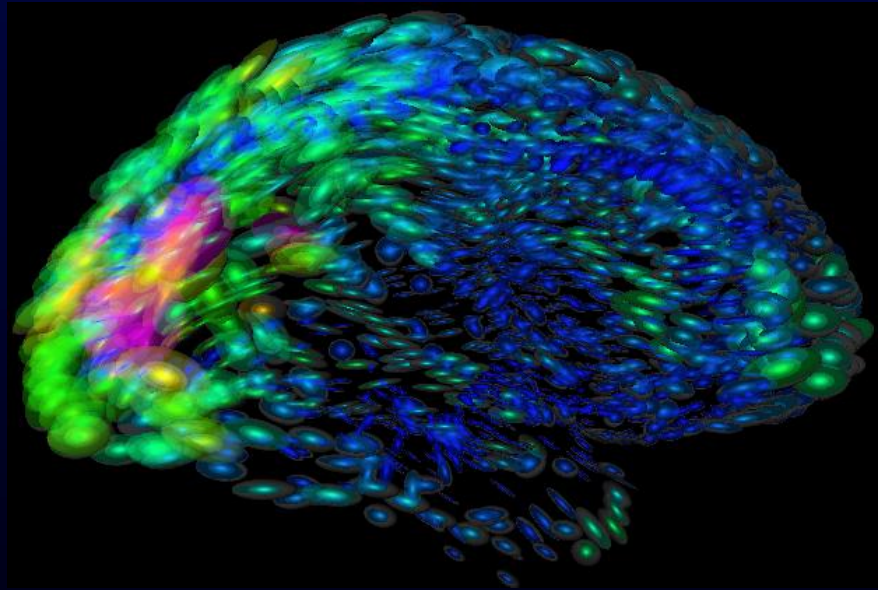
Per mesh node:

$$T = \sum v_i v_i^T$$

Glyph Representation

$$T = R \Lambda R^{-1}$$

$$= \begin{bmatrix} | & | & | \\ v_1 & v_2 & v_3 \\ | & | & | \end{bmatrix} \begin{bmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda_3 \end{bmatrix} \begin{bmatrix} - & v_1 & - \\ - & v_2 & - \\ - & v_3 & - \end{bmatrix}$$

Results with Ellipsoids

Thompson et al., 2001

Ellipsoid problem: visual ambiguity

one viewpoint:
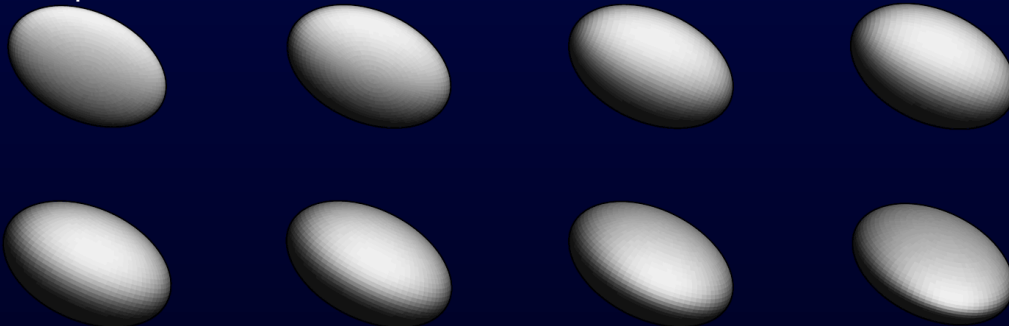
another viewpoint:
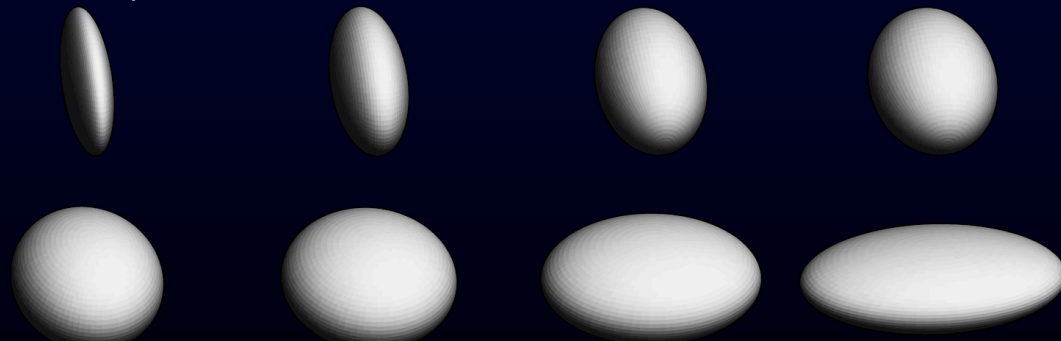
Solution: superquadrics
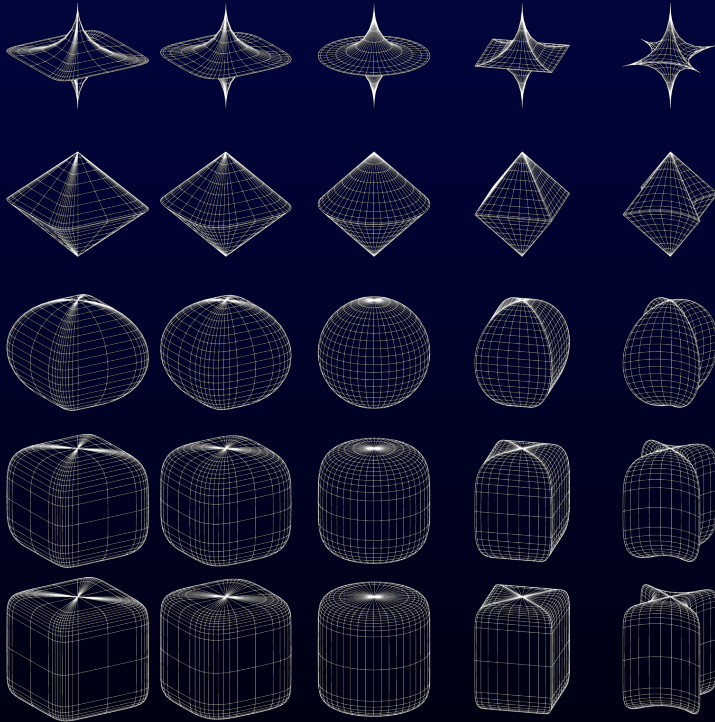
Barr, 1981

For computer vision:
Pentland, 1986

For visualization:
Shaw + Ebert,
1998, 1999, 2000, 2001

Diffusion Tensors:
Kindlmann, 2004

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Superquadric Glyph Method
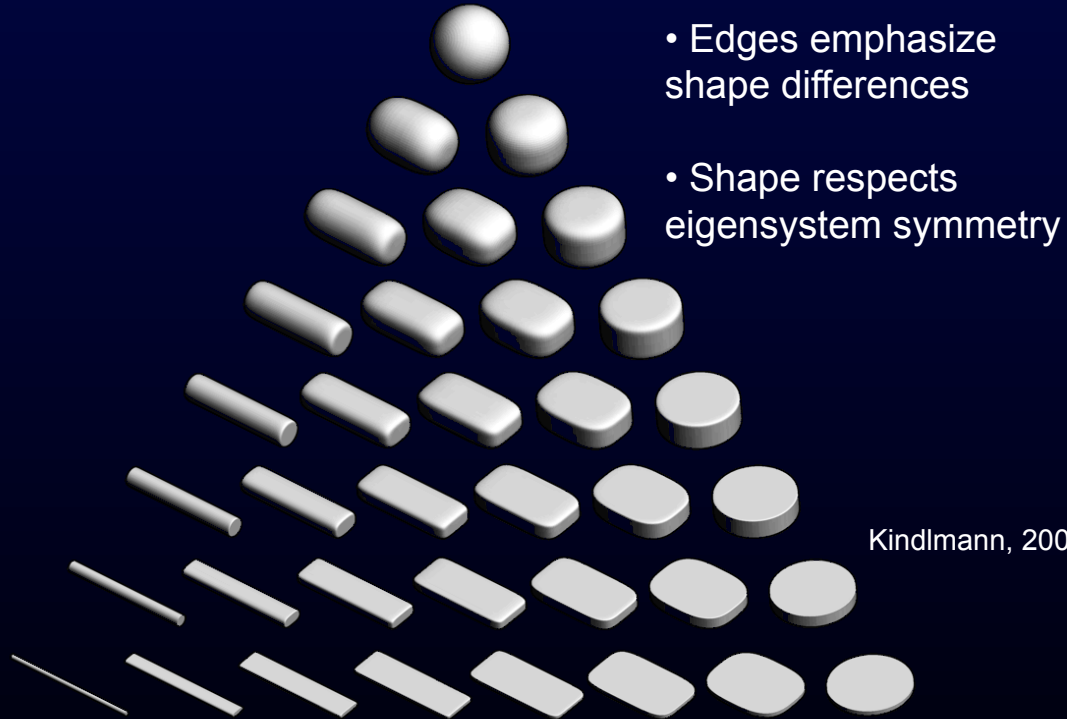
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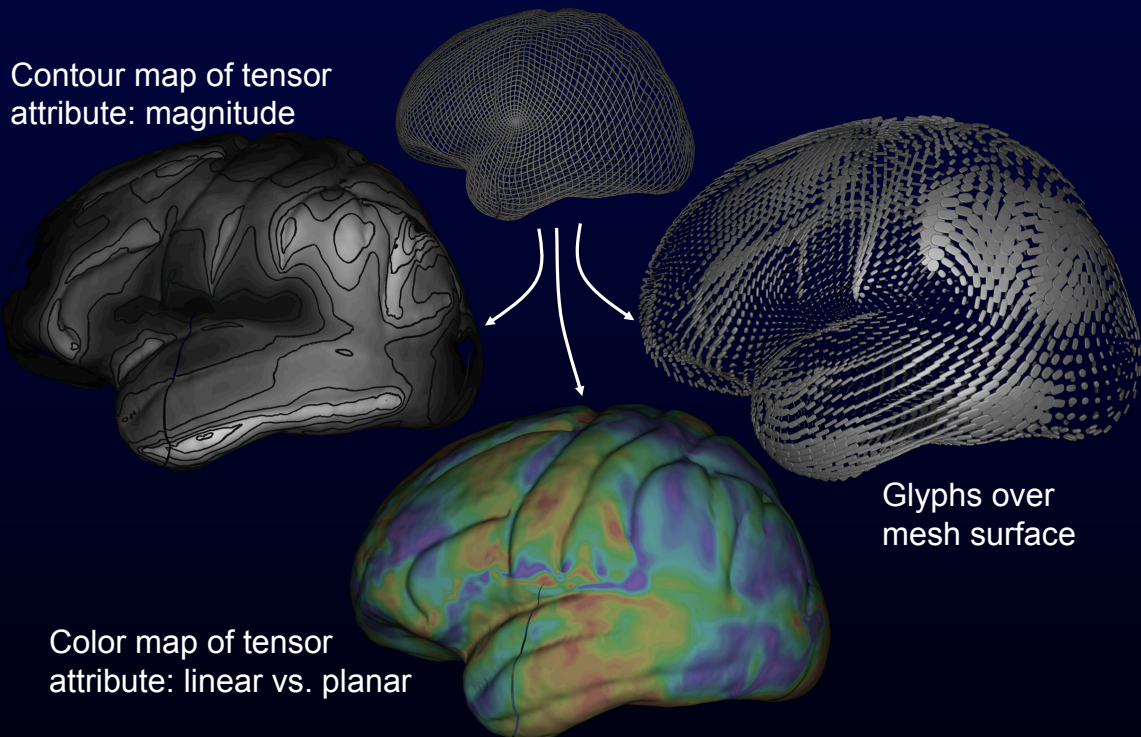
Superquadric Glyph Method, cont.

- Edges emphasize shape differences

- Shape respects eigensystem symmetry

Kindlmann, 2004

Covariance tensor visualization method

Contour map of tensor attribute: magnitude

Glyphs over mesh surface
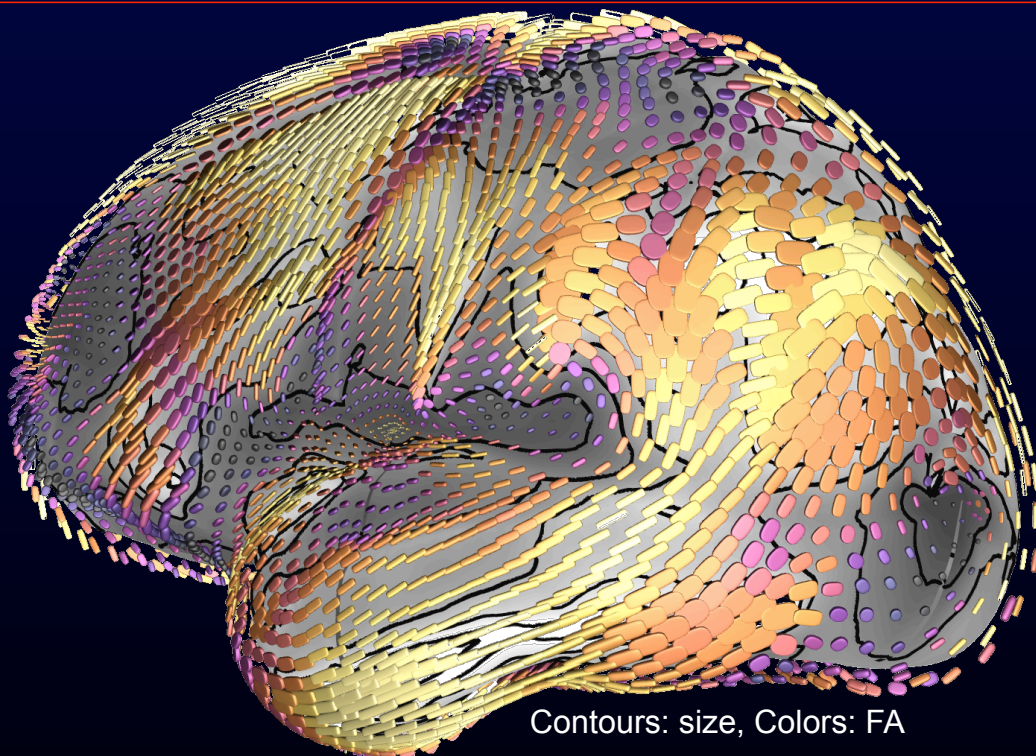
Color map of tensor attribute: linear vs. planar
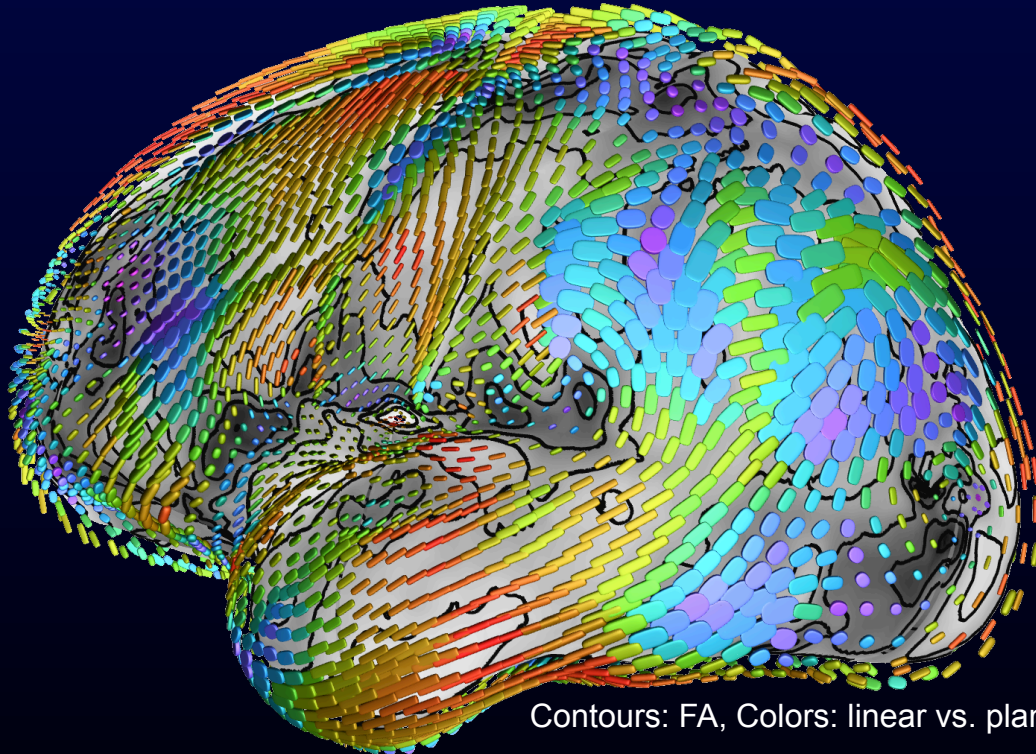
Results

Contours: FA, Colors: linear vs. planar

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Results
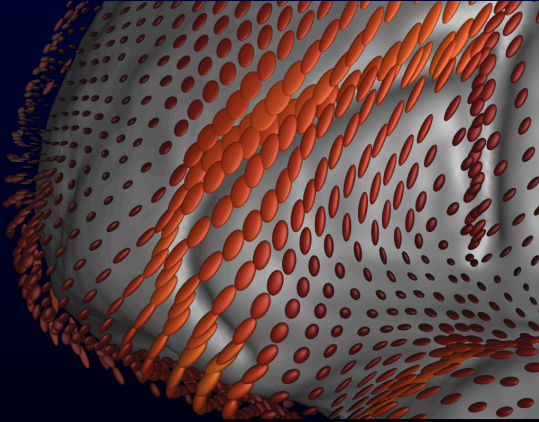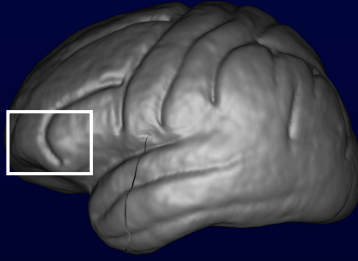
Contours: size, Colors: FA

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Comparison

ellipsoids

superquadrics
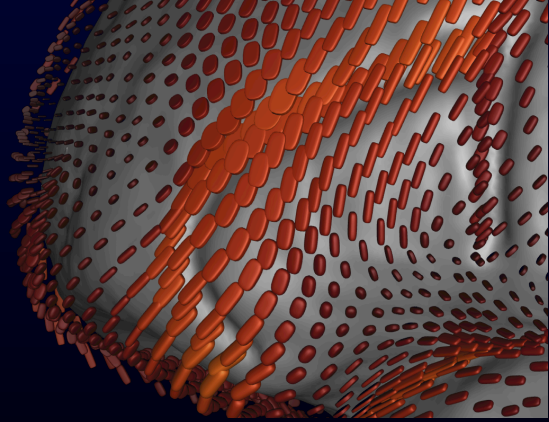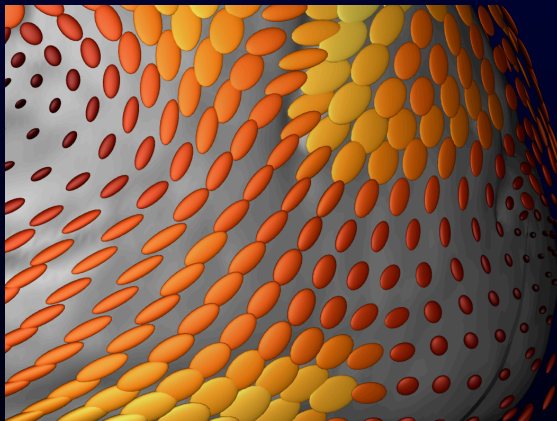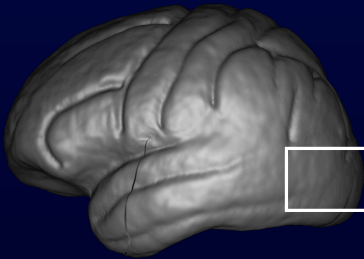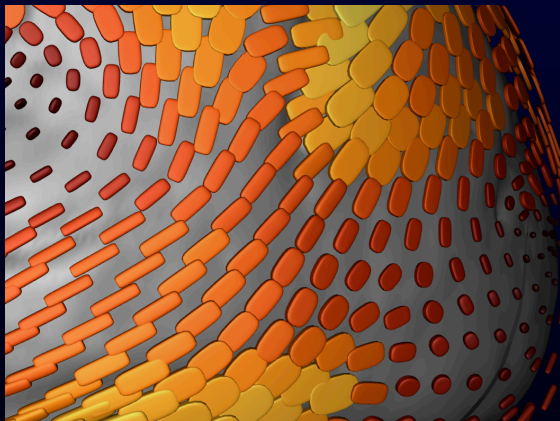
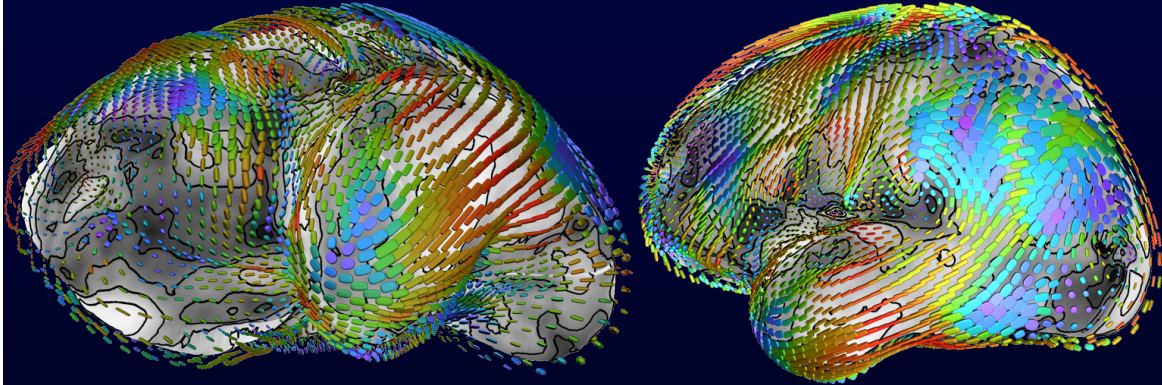Visualization of Anatomic Covariance Tensor Fields

Comparison

ellipsoids

superquadrics

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Discussion

Relationship to:
• brain function (language areas, sensory, motor)
• developmental stages
• evolutionary stages

Future work:
• Quantify relationship to underlying diffusion tensors
• Other visualization methods (streamlines)

All software open-source:

`http://software.sci.utah.edu`

Questions?