

# Diffusion Tensor Visualization With Glyph Packing

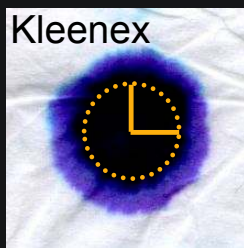
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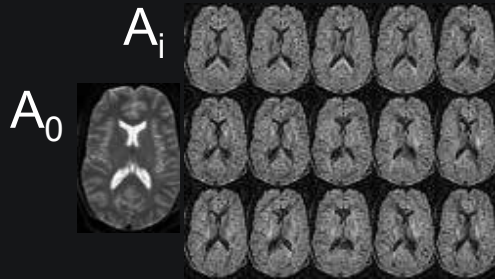
## Diffusion tensor imaging (DTI)

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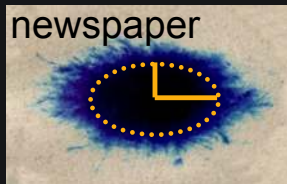
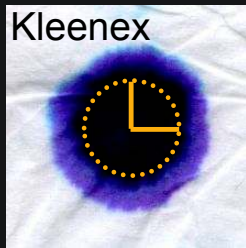
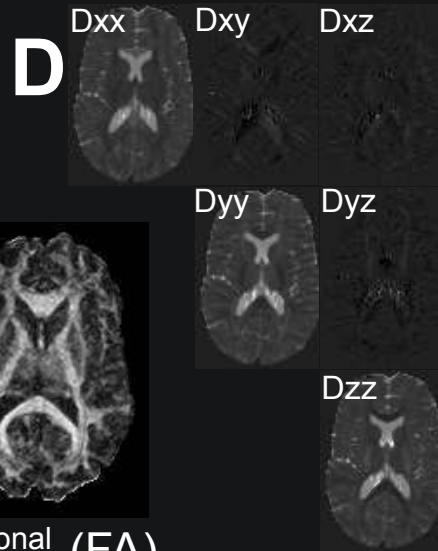
anisotropy

# Diffusion tensor imaging (DTI)

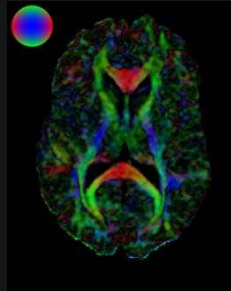


$$A_i(b, \mathbf{g}) = A_0 e^{-b \mathbf{g}_i^T \mathbf{D} \mathbf{g}_i}$$

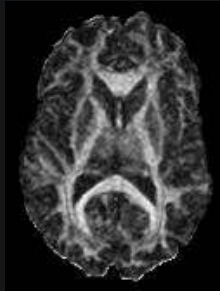
(Basser 1994)



anisotropy

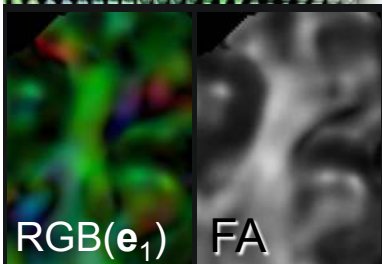
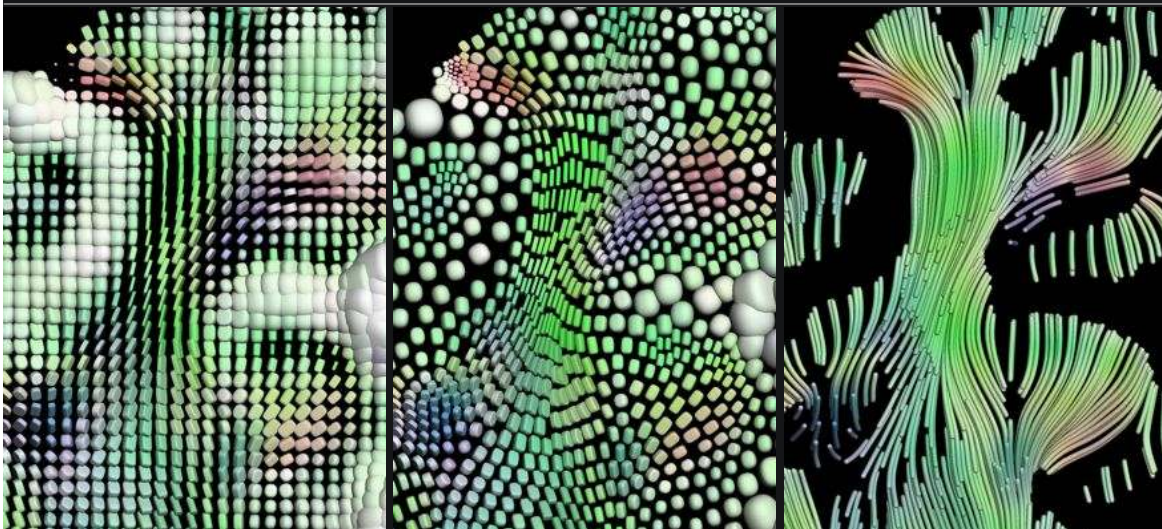


RGB( $\mathbf{e}_1$ )



fractional anisotropy (FA)

# Glyph packing compared to grid, fibers

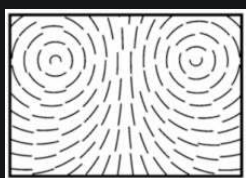


RGB( $\mathbf{e}_1$ )

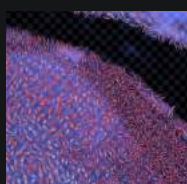
FA

Formation of **discrete** glyphs into a **continuous** texture  
Need tensor interpolation

## Textures



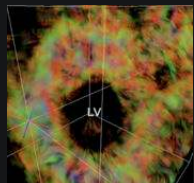
Turk & Banks '96



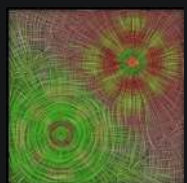
Laidlaw et al. '98



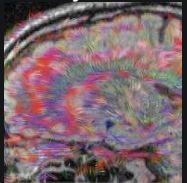
Kirby et al. '99



Sigfridsson et al. '02

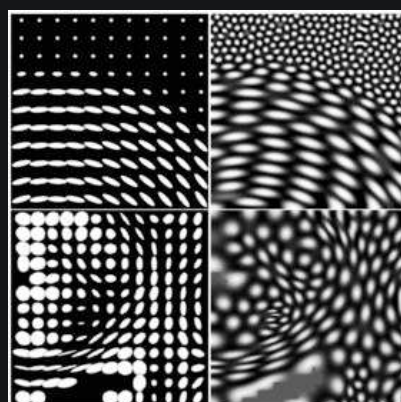


Hotz et al. '04



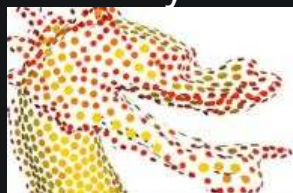
Benger et al. '06

## Reaction-Diffusion



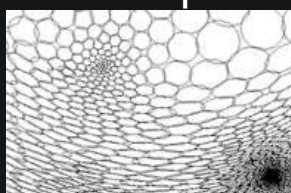
Kindlmann et al. '00

## Particle systems

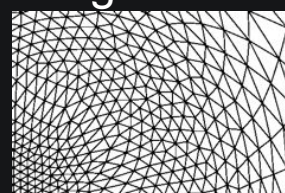


Meyer et al. '05

## Anisotropic Meshing



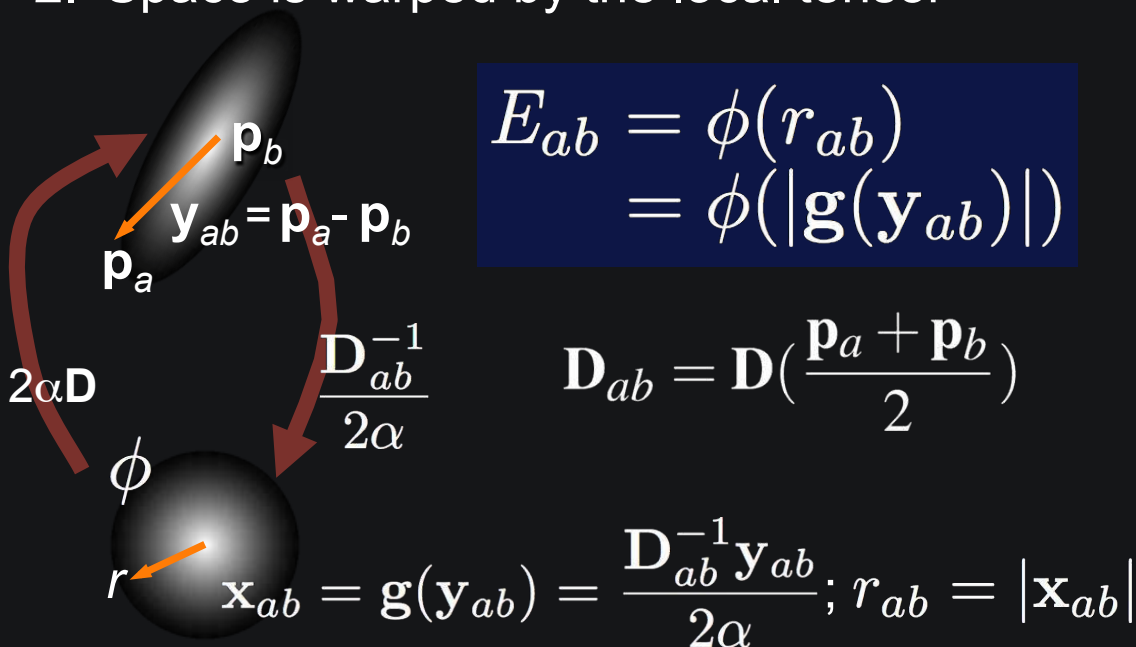
Shimada et al. '00



Bossen et al. '96

# Tensor-based potential energy

1. Particles push each other away
2. Space is warped by the local tensor



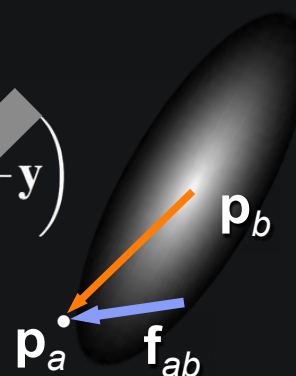
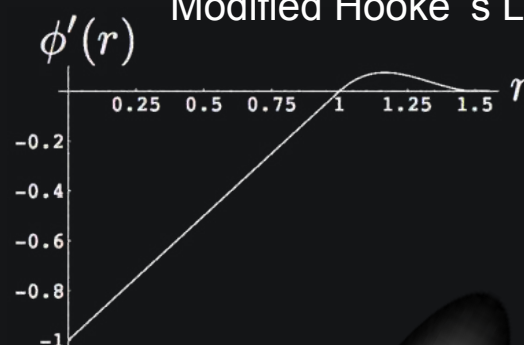
$$E = \phi(|\mathbf{g}(\mathbf{y})|)$$

$$\frac{dE}{d\mathbf{y}} = \frac{dE}{dr} \frac{dr}{d\mathbf{x}} \frac{d\mathbf{x}}{d\mathbf{y}}$$

$$= \phi'(|\mathbf{x}|) \frac{\mathbf{x}^T}{|\mathbf{x}|} \frac{1}{2\alpha} \left( \mathbf{D}^{-1} + \frac{d\mathbf{D}^{-1}}{d\mathbf{y}} \mathbf{y} \right)$$

$$\mathbf{f}_{ab} = -\frac{\phi'(|\mathbf{x}_{ab}|)}{2\alpha} \mathbf{D}_{ab}^{-1} \frac{\mathbf{x}_{ab}}{|\mathbf{x}_{ab}|}$$

Modified Hooke's Law



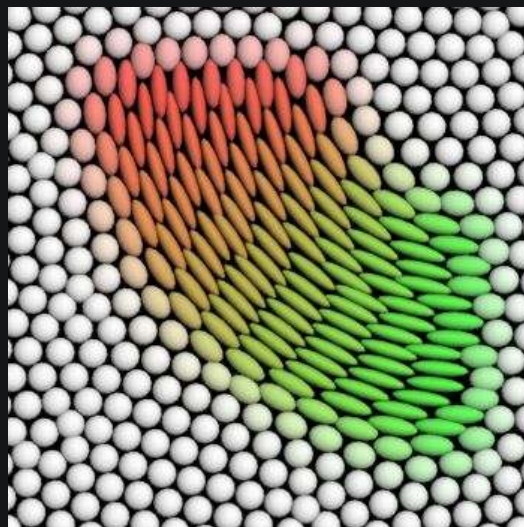
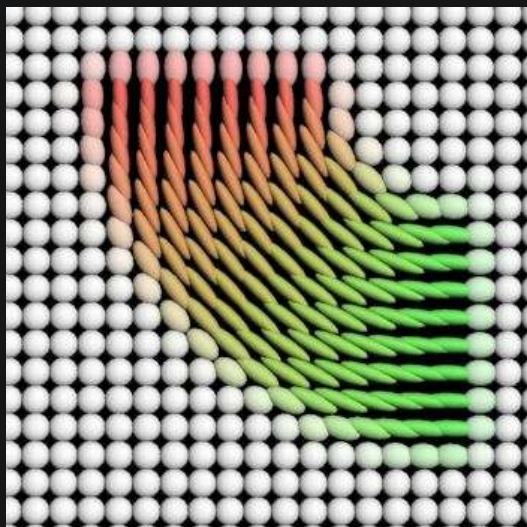
## Implementation

- Spatial Binning
- Inverse approximation :  $\mathbf{D}_{ab}^{-1} \approx \frac{\mathbf{D}^{-1}(\mathbf{p}_a) + \mathbf{D}^{-1}(\mathbf{p}_b)}{2}$
- Constraints on slices
- Solver:  $F=ma$  vs. Gradient descent
  - Order of faster convergence times than paper
- Probabilistically re-use probed tensors



## Results: synthetic data

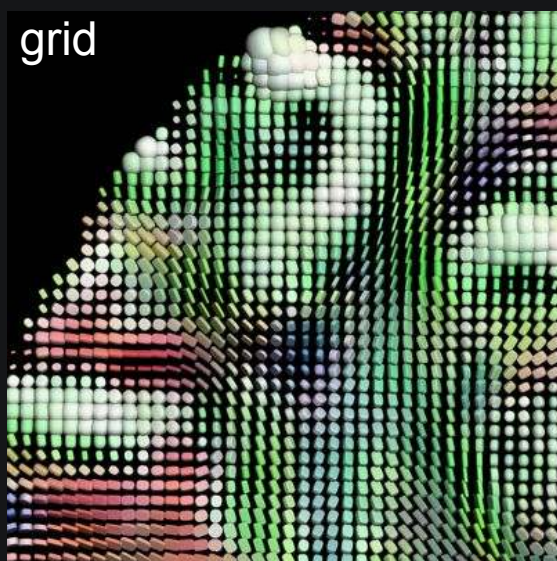
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Glyph overlap reduced  
Smoother orientation change  
Problem (?): new hexagonal grid  
Packing results can seed other glyph geometry

## Results: healthy slice

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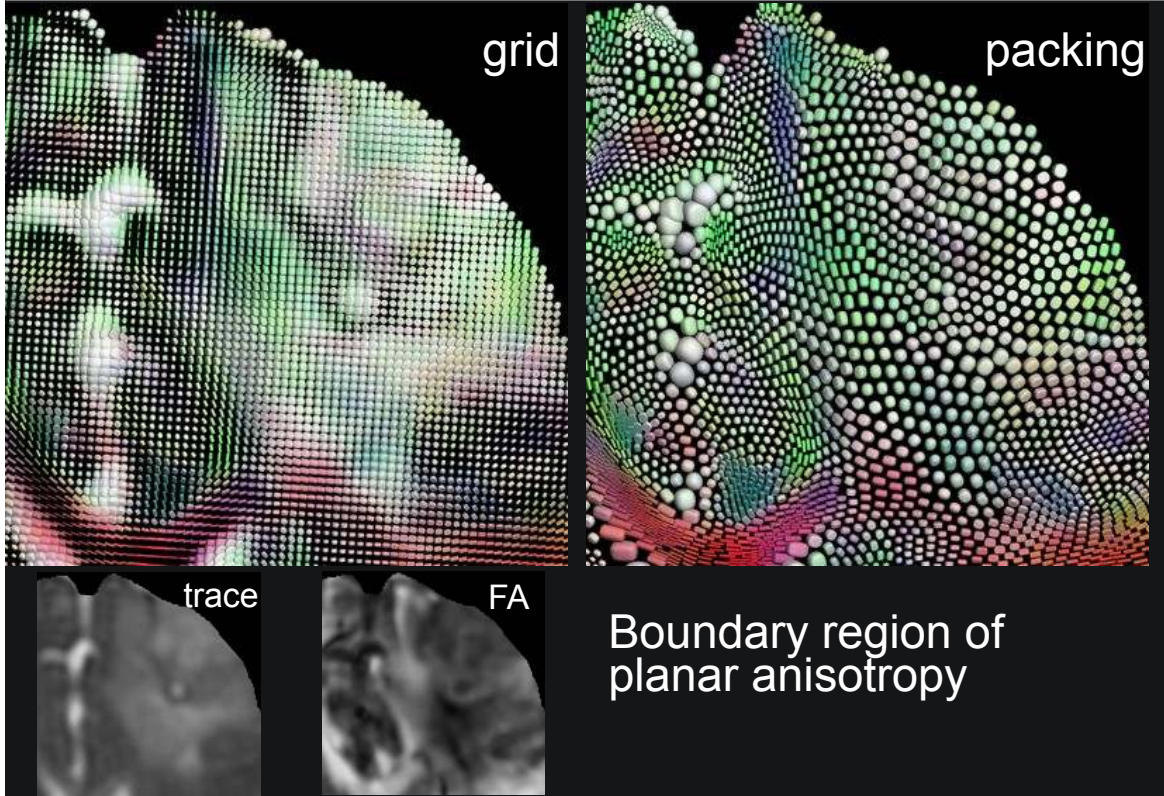


Tracts only in linear anisotropy; glyphs everywhere  
Glyph packing complements tractography



# Results: oligodendrogloma slice

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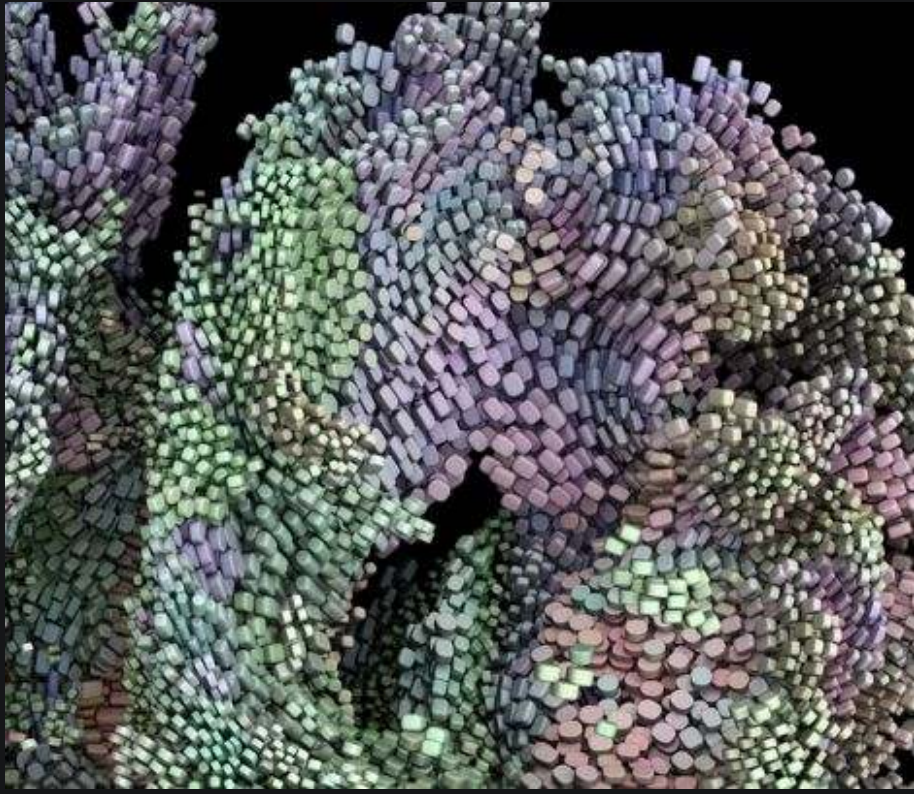


# Results: volume of glyphs

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- 3D glyphs can compose a dense, texture-like tensor field visualization in 2D or 3D.
- Particle systems have a role in tensor vis.
- Glyph-based tensor field visualizations can work in three dimensions.
- Implicit surfaces, tensor field derivative
- Rendering effects, painterly techniques
- User study? (Acevedo et al. Vis '06)

## Acknowledgements

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- Alexandra Golby, MD; U41-RR019703-01A2, Brain Science Foundation.
- URL for paper + software info:  
<http://lmi.bwh.harvard.edu/~gk/vis06/>

thank you