Hierarchical Statistical Modeling of Boundary Image Profiles

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Bayesian image segmentation

$$\log p(m \mid I) = \log p(m) + \log [p(I \mid m) / p(I)]$$

Geometric prior

Image match

Model-based segmentation

Shape typicality ("prior")	Model-to-image match

■ Shape representation
  ■ PDM, SPHARM, M-rep, level-set, etc.
■ Probabilistic model
  ■ Likelihood of a given shape
	■ Image representation
	  ■ Global (no corresp.)
	  ■ Local (req. corresp.)
	■ Probabilistic model
	  ■ Fit of a given shape in a given image

Example: corpus callosum

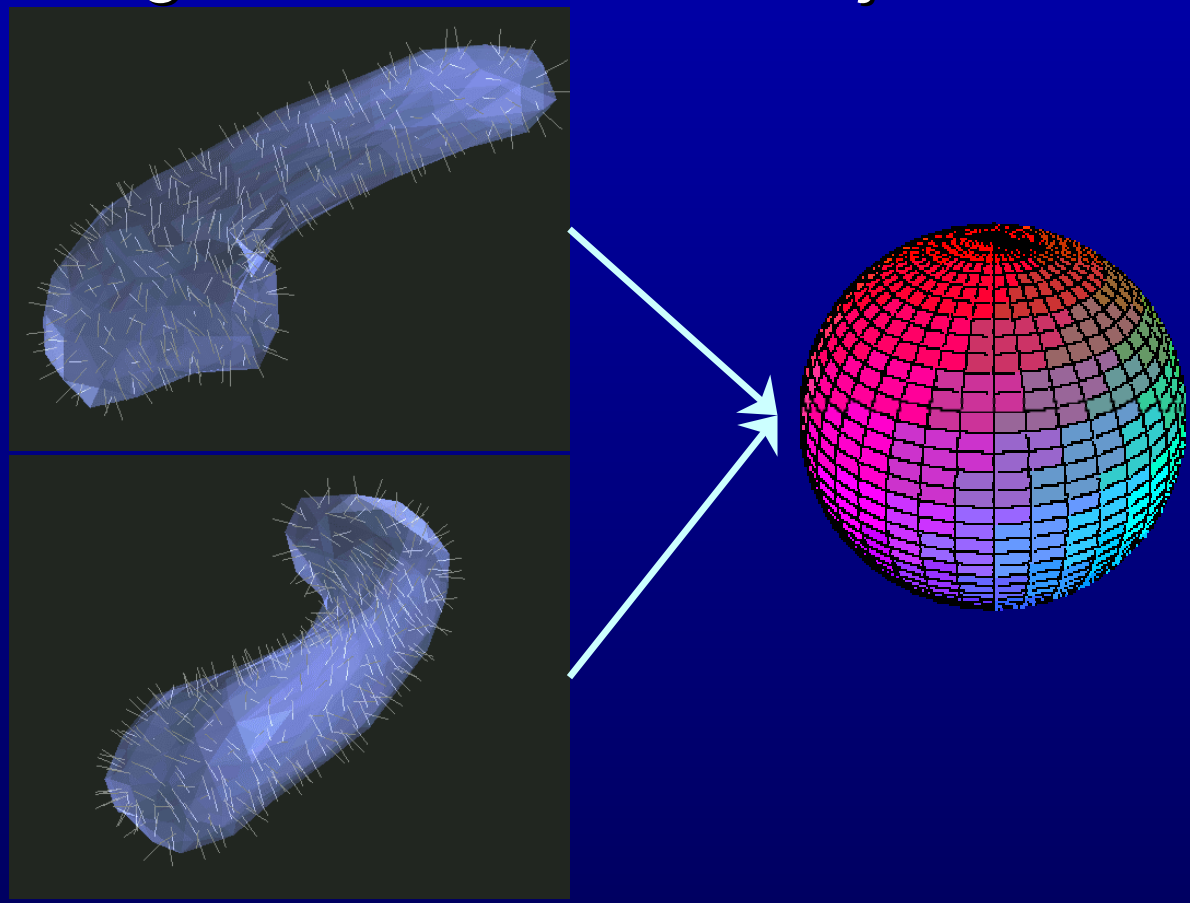
- Automatic segmentation
- Shape rep: 2D Fourier (Staib et al)
- Image rep: 1D profiles normal to boundary (Cootes et al)
  - Each profile independent of its neighbors
  - 100 profiles => 100 separate PCAs
- (movie)

Some examples of related work

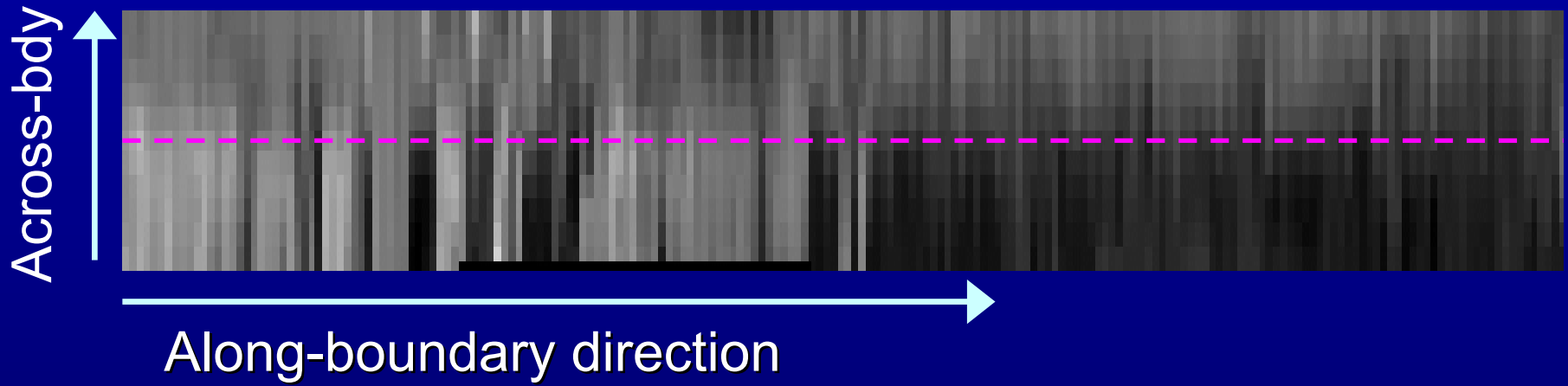
- Snakes: gradient magnitude
  - Also region-based inside/outside snakes
- Template matching, correlation
- ASM/SPHARM: independent profiles
- AAM: hierarchical over whole image

Object-intrinsic coordinates

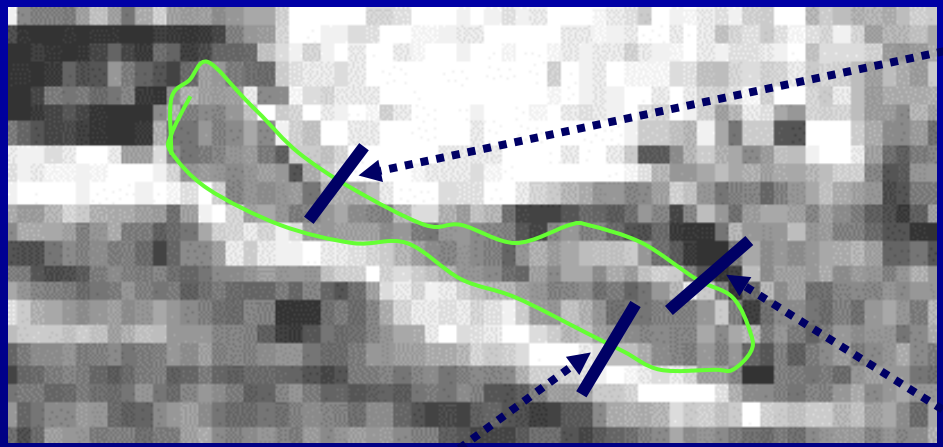
- Use SPHARM parameterization to sample image in collar around object boundary

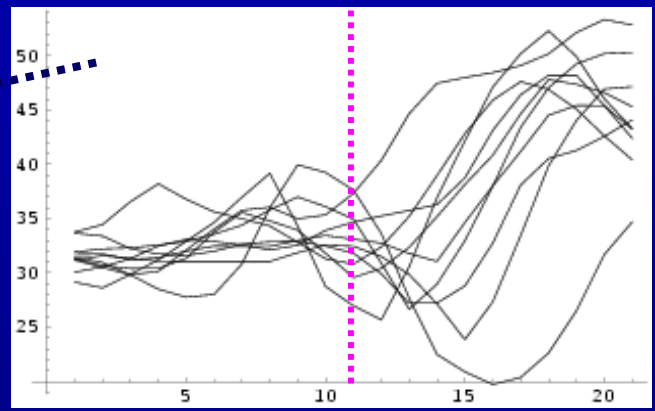


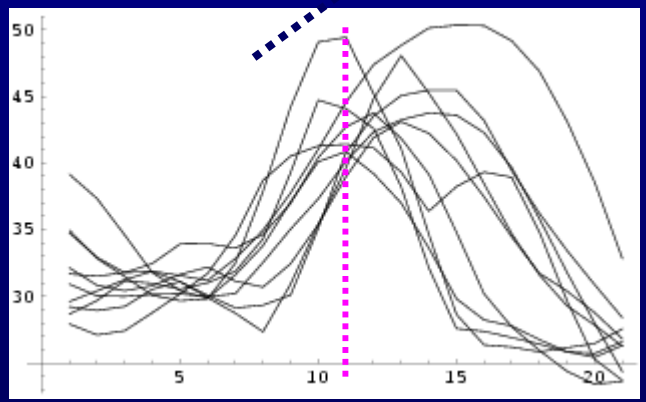
Profiles in normalized coords

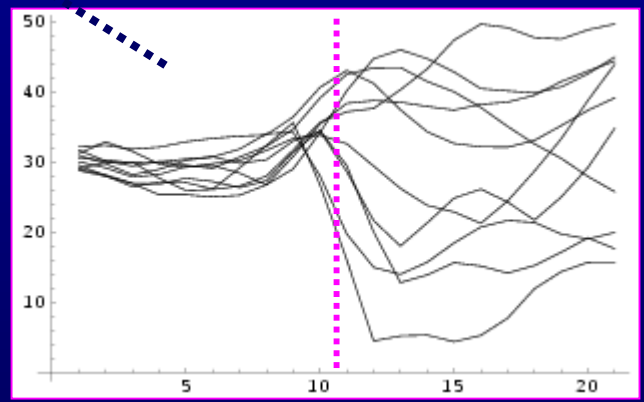


Across-boundary model



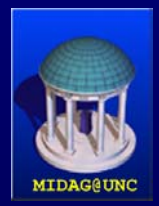






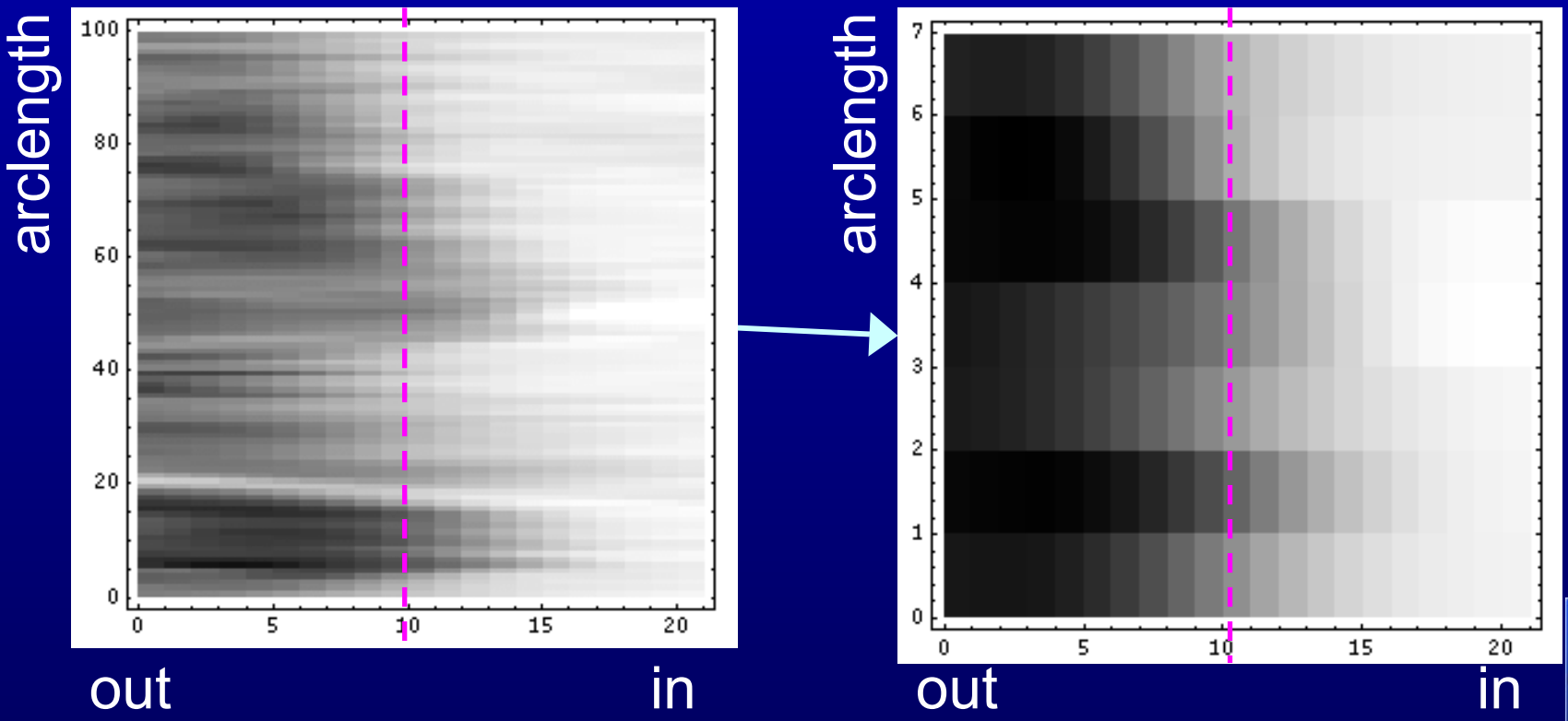
Driving Questions

- fine sampling necessary?
  - pyramid
  - object specific
- how do we deal with noise?
  - would like to blur along boundary
- local statistical model

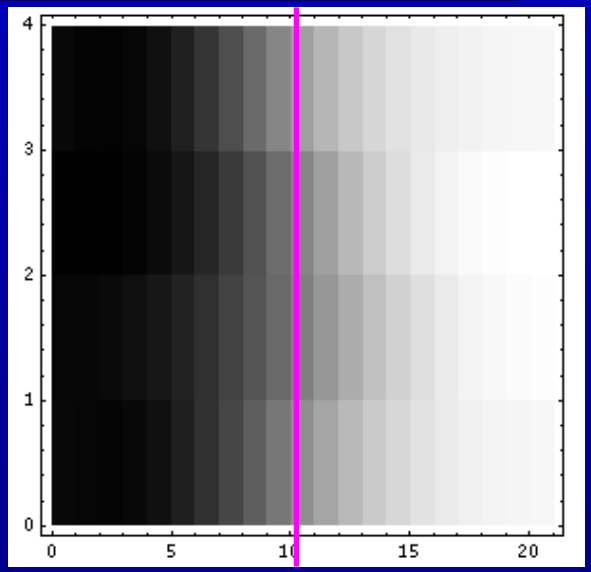


Along-boundary model

- Gaussian profile pyramid



Laplacian profile pyramid



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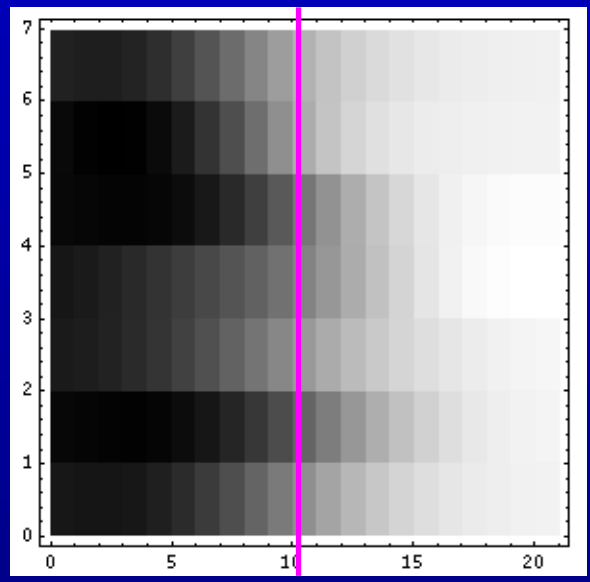

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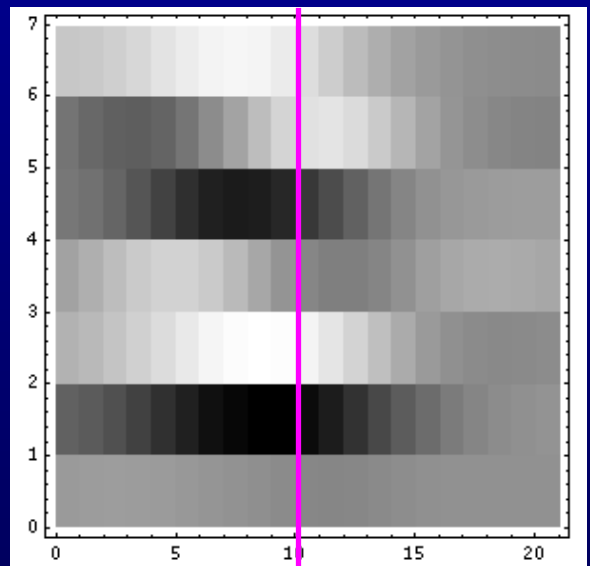
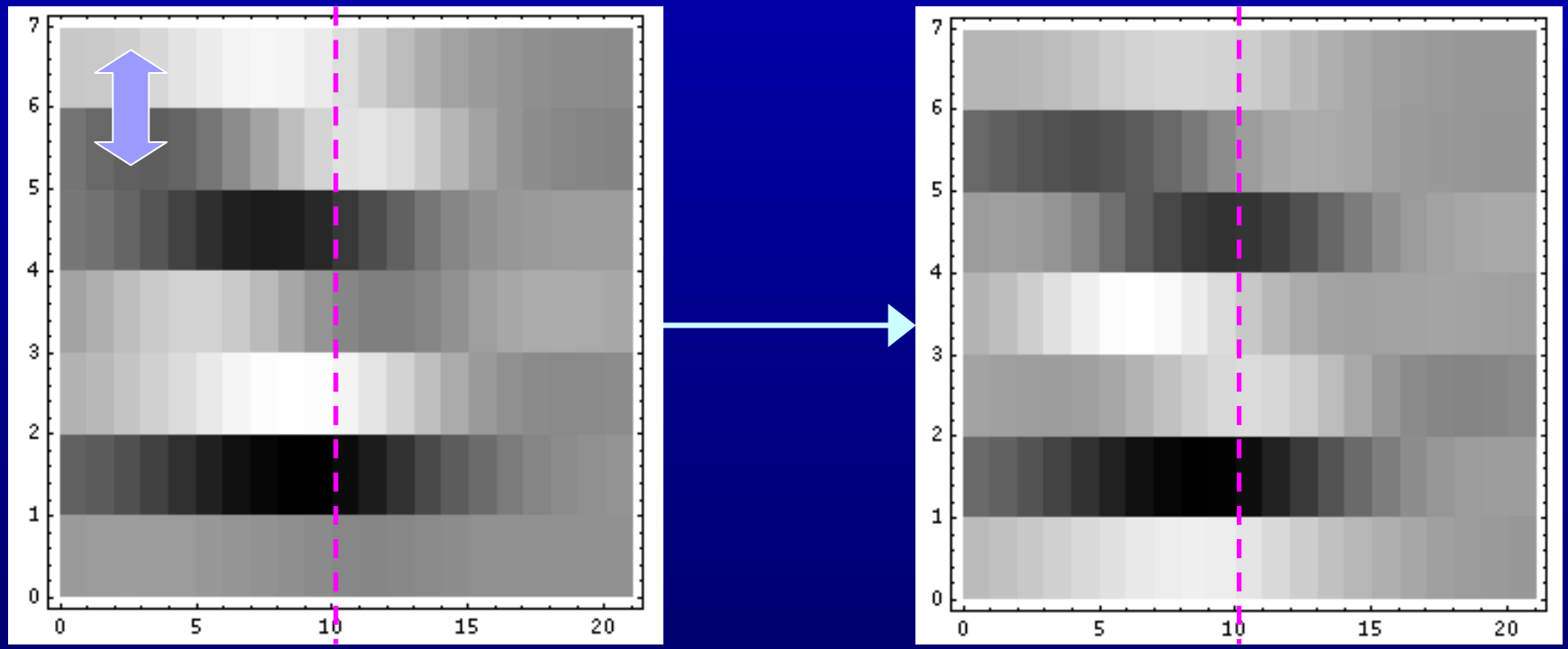


- $\partial/\partial\sigma$

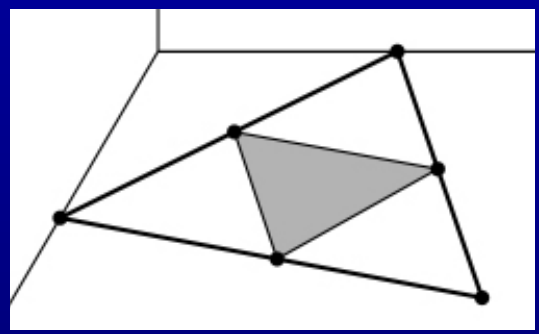
Laplacian, local differences

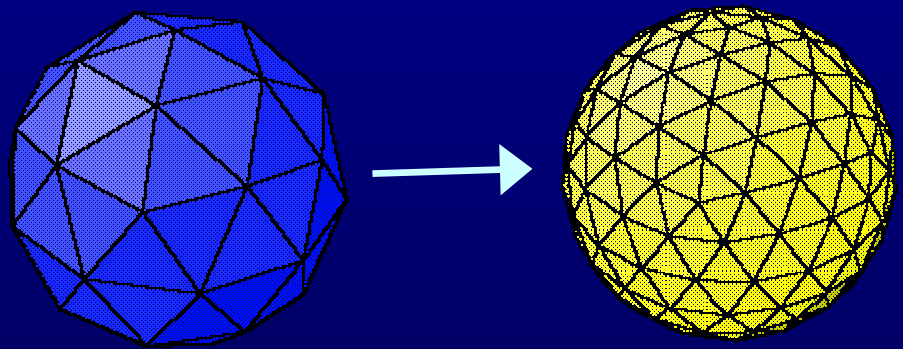
- $\partial/\partial\sigma$ $\partial/\partial u$



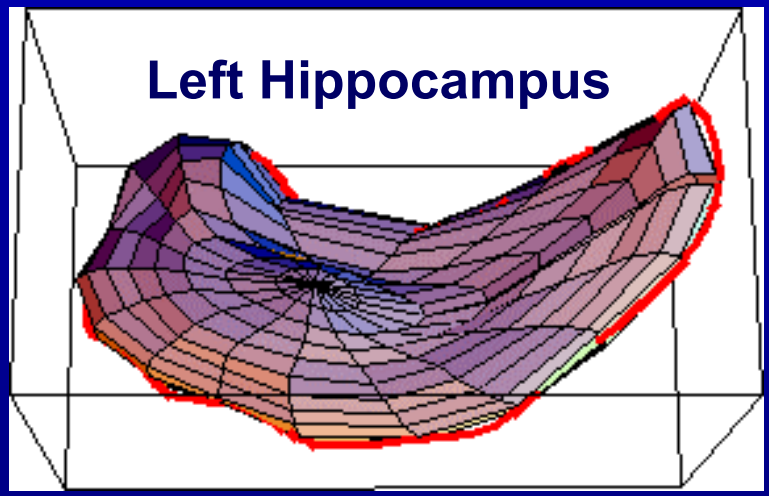
Profiles in 3D

- Use SPHARM parameter space of unit sphere
- Recursive subdivision with icosahedron
  - 0^{th} level: 20 profiles
  - 1^{st} level: 20*4 profiles
- 1-way Markov chain

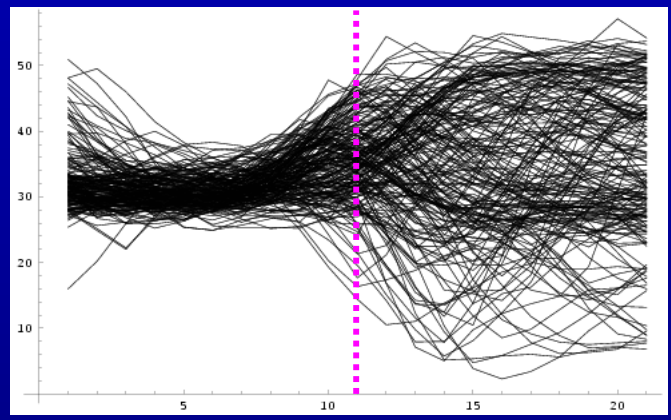




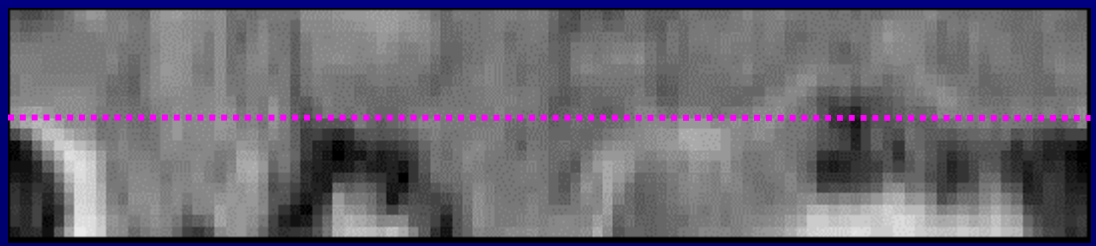
Profiles along 1 object in 3D



All profiles



Inside **Outside**



Inside

Outside

Profiles along red meridian line

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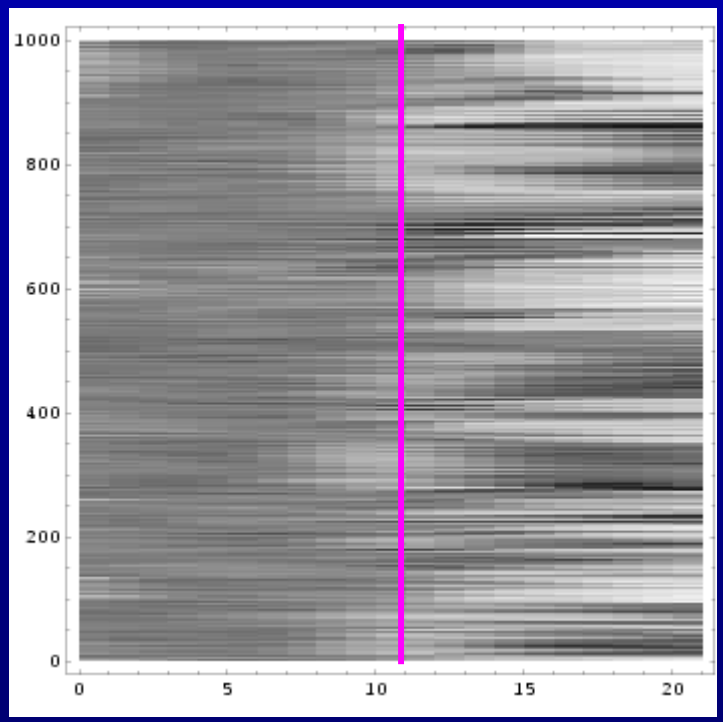
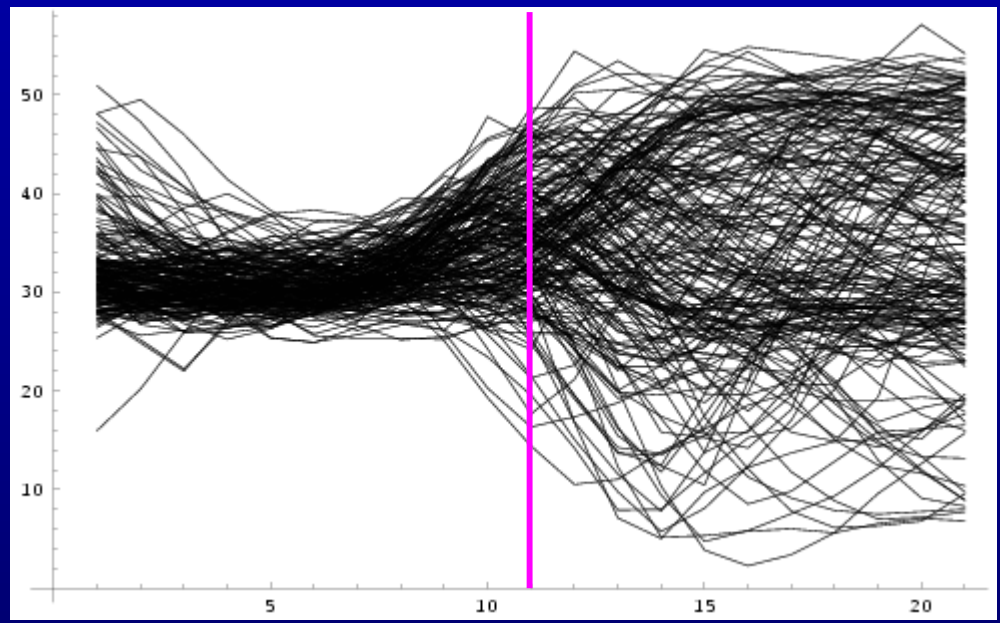
Profiles around 1 hippocampus



Inside Outside



Inside Outside

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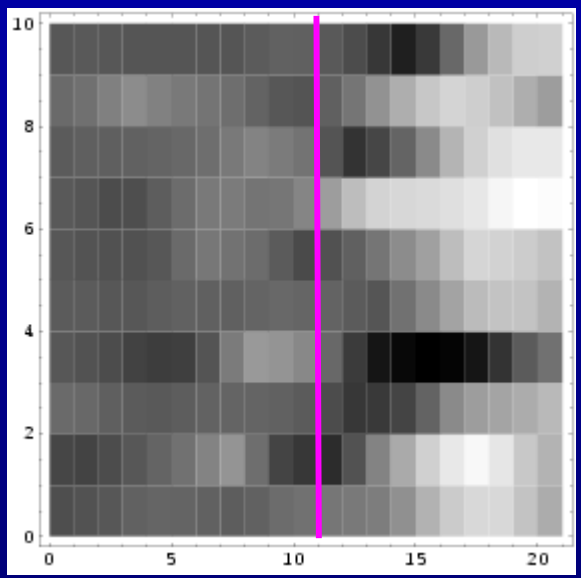
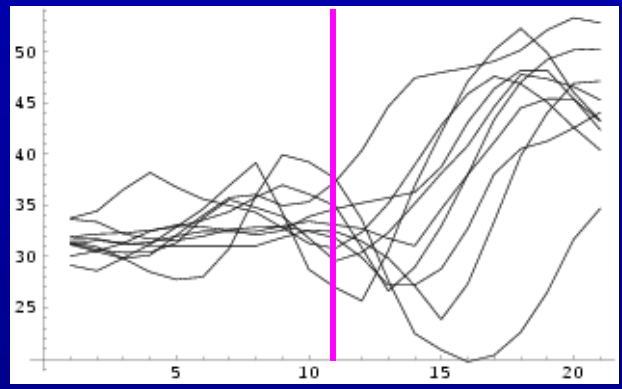
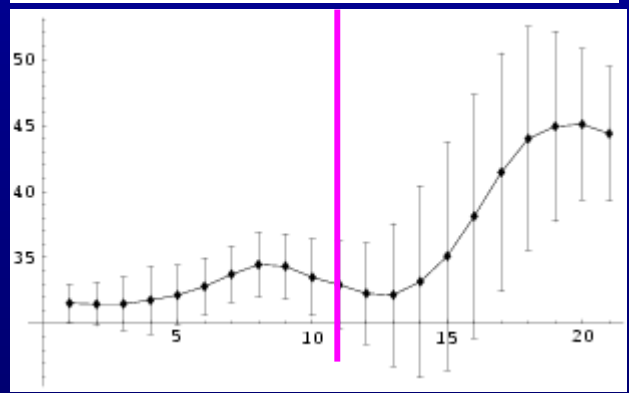
Profiles: at 1 point on boundary

- 1 corresponding point on population of 10 hippocampi



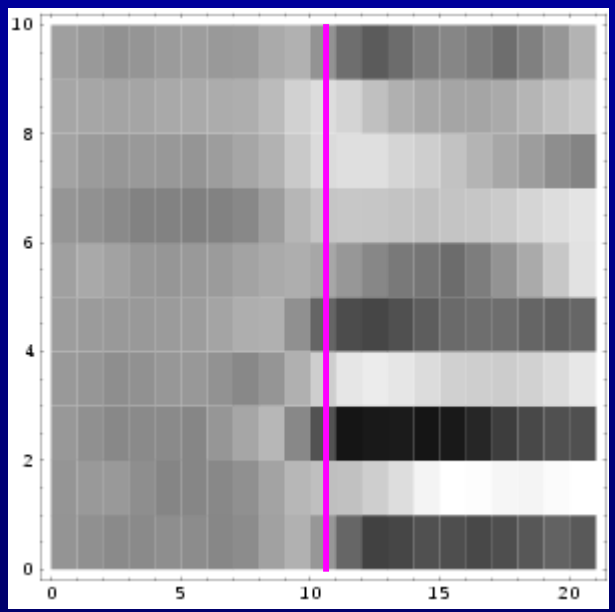


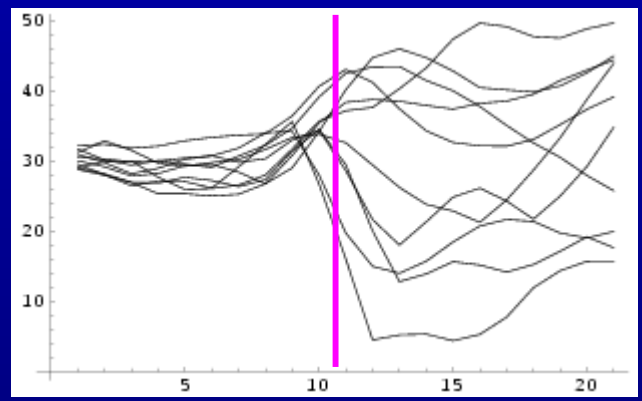


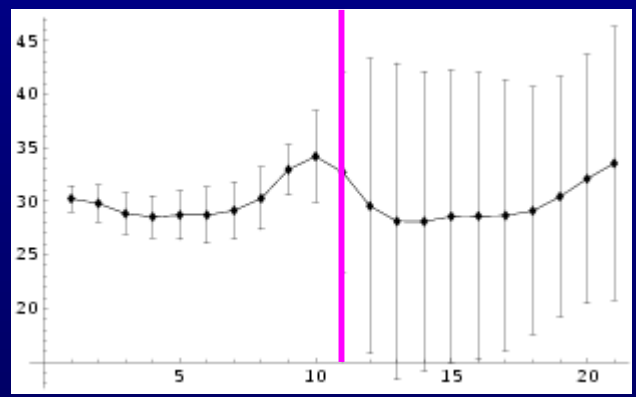
- Step-edge visible
- More variability outside

At another point on boundary

- Large variability across subjects
- Mean profile nearly flat: low confidence







Current / ongoing work

- SPHARM segmentation framework:
  - Standard ASM-like independent profiles
  - New hierarchical along-boundary model
  - New statistical model (local PCA, MRF)
- Testbed in 2D with 71 corpora callosa
- Testbed in 3D with:
  - 90 caudates (L/R)
  - 90 hippocampi (L/R)

Profile Pyramid

- Average of 20
- multiscale along boundary
- Image match model for segmentation