STRUCTURAL VOLUME AND SURFACE ANALYSIS

LONI pipeline structural analysis tools

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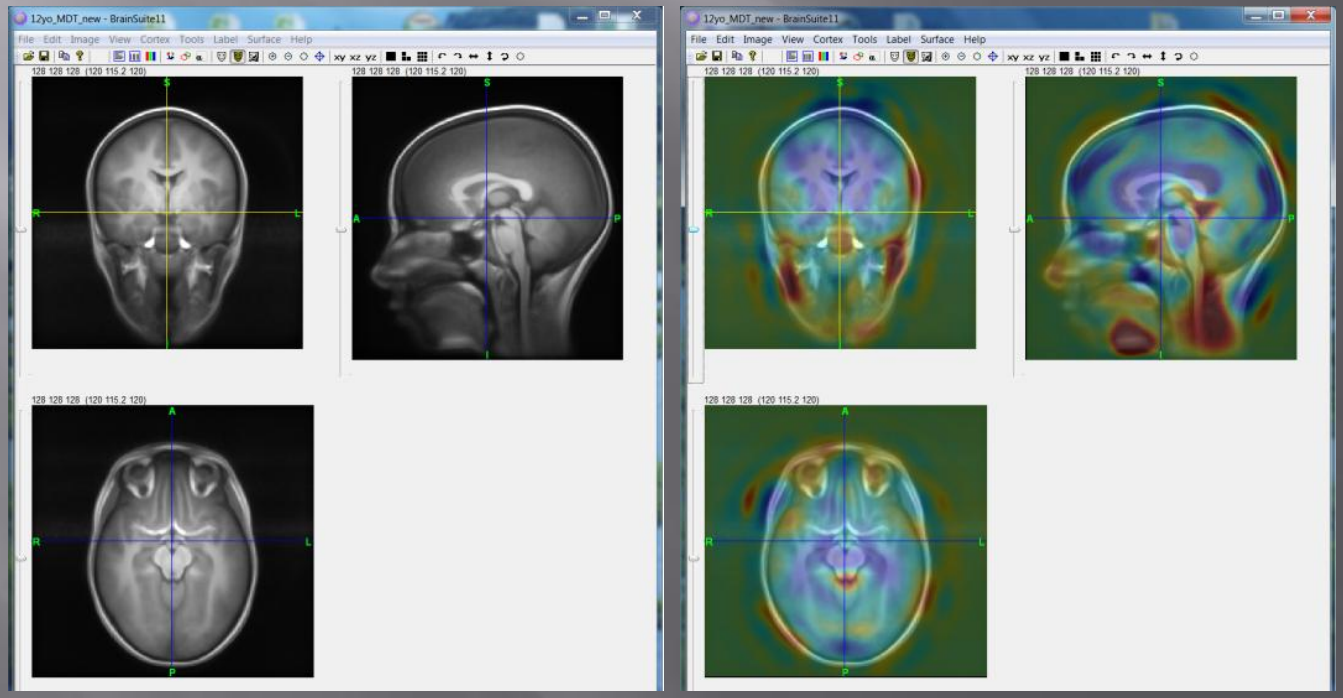
Volume Registration & TBM

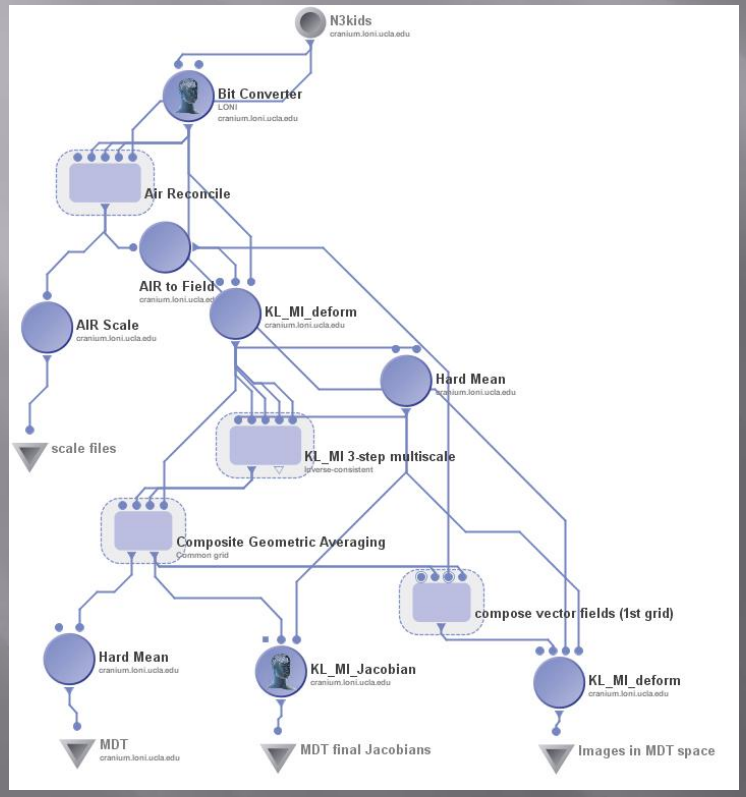
- Atlas creation (Minimal Distance Template)
- Tensor-based morphometry (TBM)



Screen shots from BrainSuite

Atlas Creation

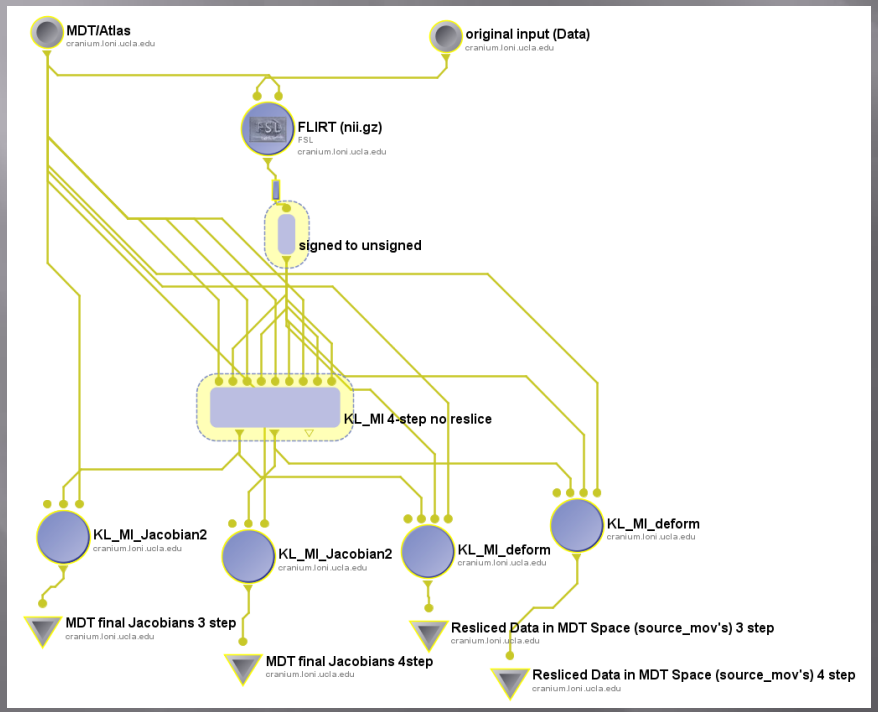
From a set of unregistered images, this workflow creates an atlas & registers all images.

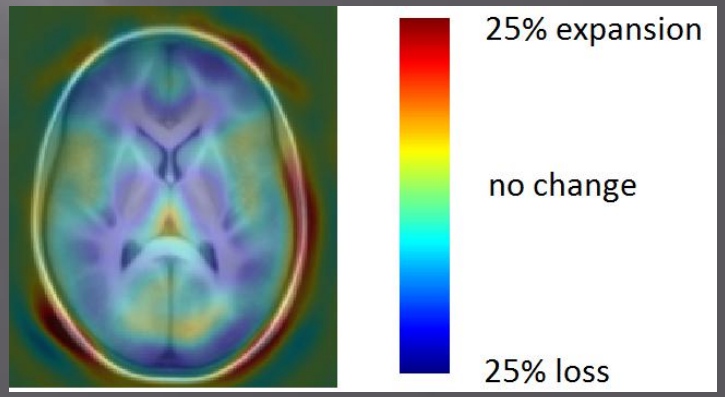


- Images are affinely registered as a group (no target selected)
- Affine mean is refined to a sharper non-linear mean in a multi-resolution fashion
- Non-linear mean warped to the "middle" of original image space

Tensor Based Morphometry

Idea: instead of computing features from intensity of one image, measure image difference. We can do this by analyzing differential properties of the warp from one image to another, i.e. properties of the Jacobian tensor. Easiest is the Jacobian determinant, scalar measure of volume change.



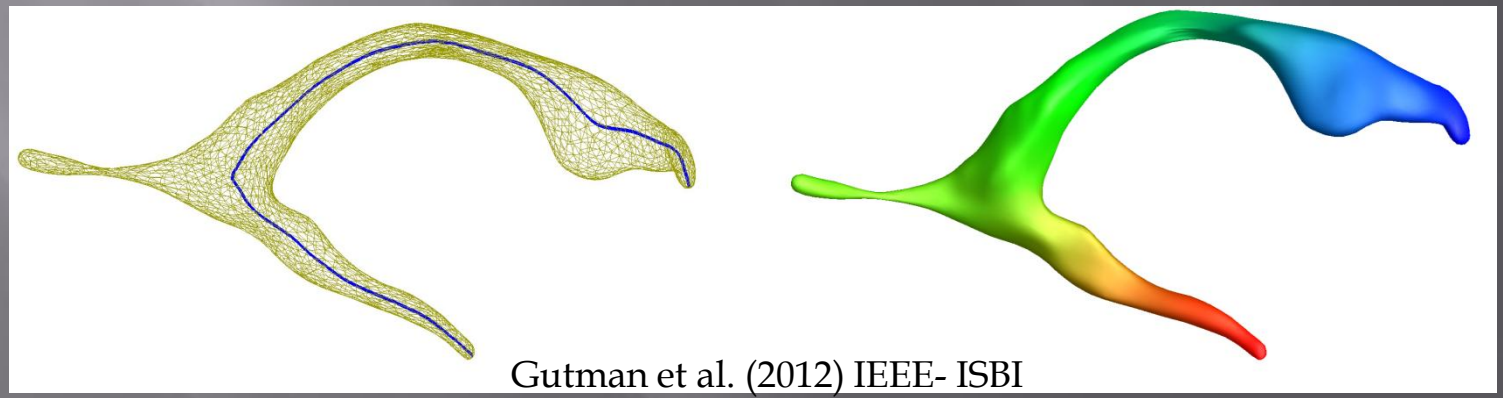


Yanovsky et al. (2007)

Jacobian map from subject-to-MDT registration

Subcortical Surface Analysis

- mask/manual trace of ROI to surface model
- surface registration
- local surface description/statistical analysis

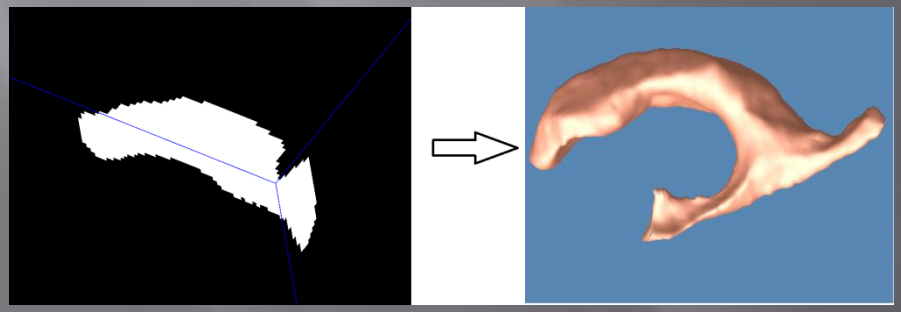


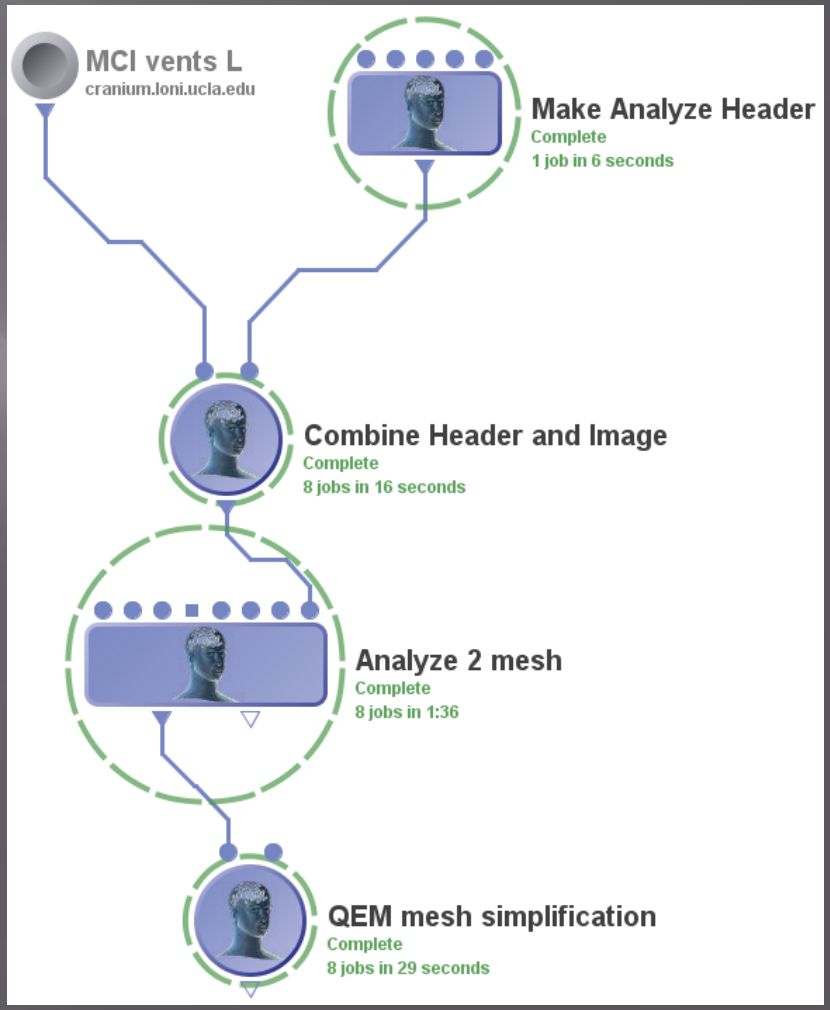
Gutman et al. (2012) IEEE- ISBI

Mask to Surface Model

Desirable properties:

- Mesh geometry faithful to mask
- Consistent topology
- Quality Triangulation
- Fast

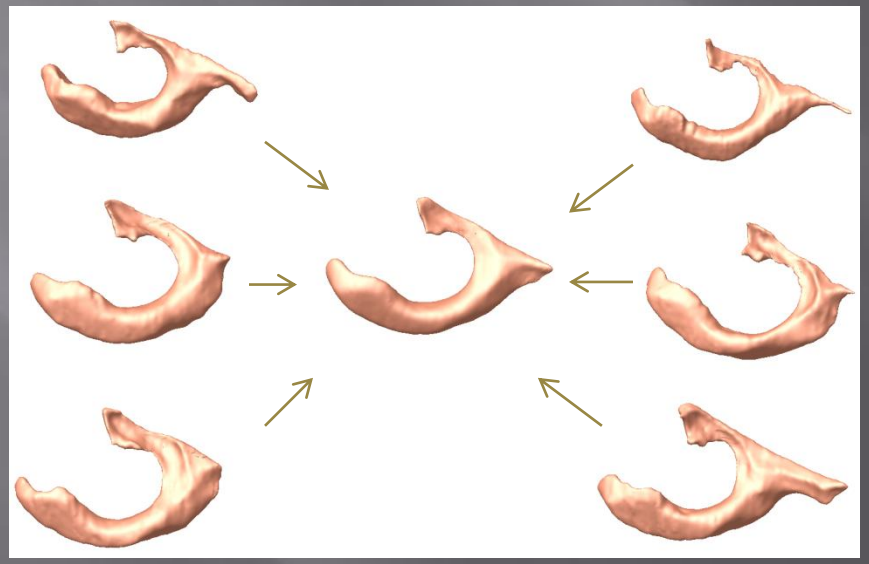




Surface Registration & Description

Desirable properties:

- Correspondence is a "near-isometry"
- Intuitive local description (e.g. shape "thickness")
- Registration is description-aware



Gutman et al. (2012) IEEE- ISBI

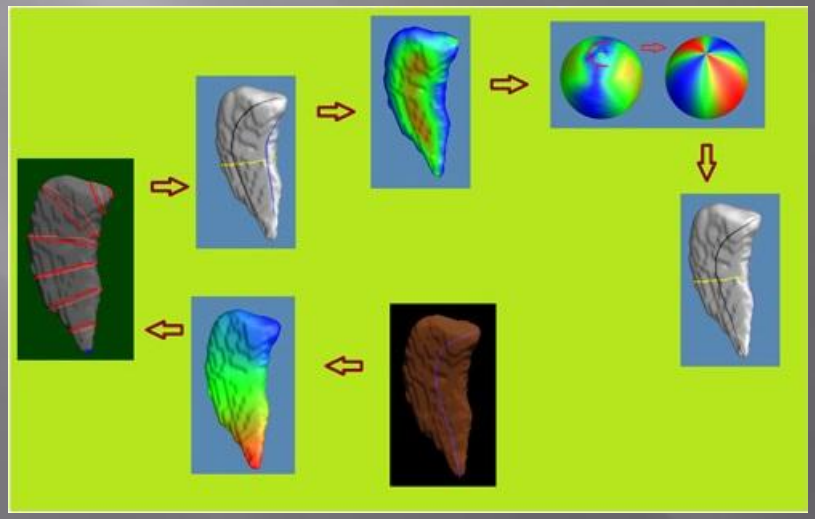
Pipelines for Surface Analysis I

Assume that the shape is very approximately tubular. Idea: find medial curve $\boldsymbol{c}(t)$ of the shape, and use the curve to induce two scalar functions on the shape.

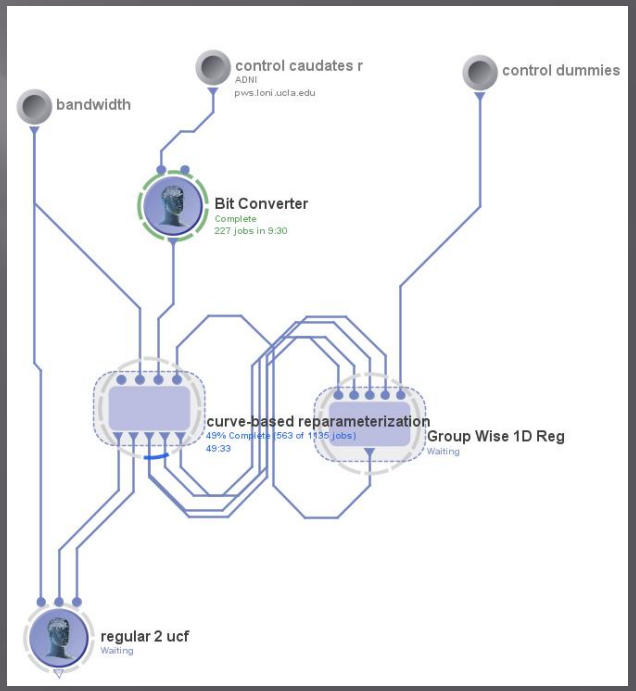
(GOF) $$G(\boldsymbol{p}) = \arg\min_{t}\{\|\boldsymbol{c}(t) - \boldsymbol{p}\|, t\epsilon[0,1]\}$$

(Thickness) $$D(\boldsymbol{p}) = \|\boldsymbol{c}(G(\boldsymbol{p})) - \boldsymbol{p}\|$$

Then, match shapes by minimizing L^2 distance between the two functions.



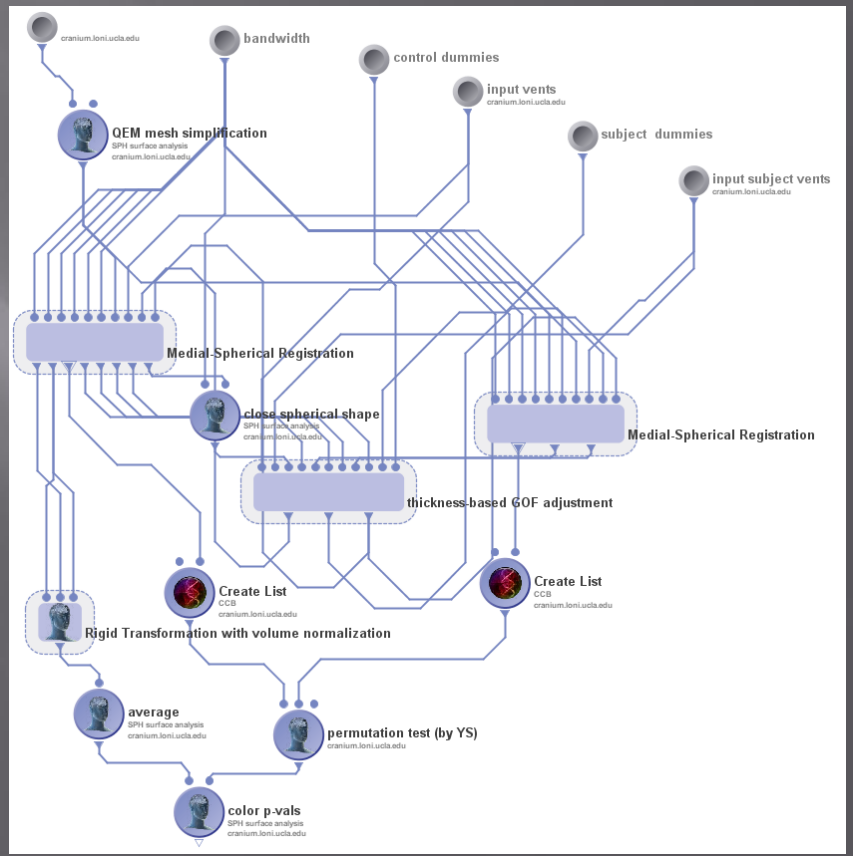
Gutman et al. (2012) OHBM

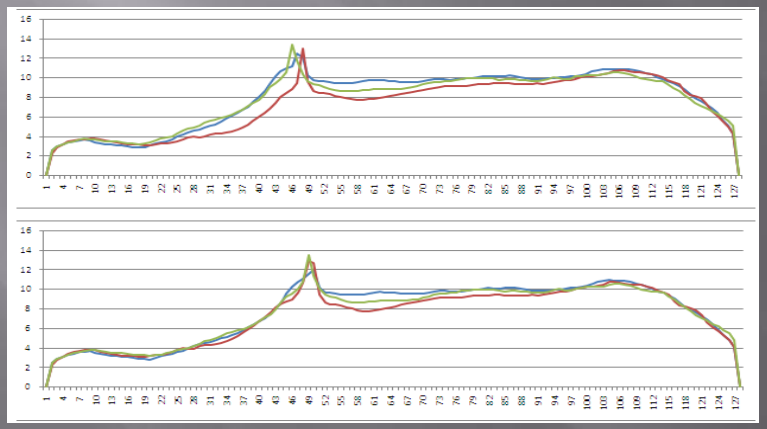


Pipelines for Surface Analysis II

Making registration more isometric and descriptor-aware:

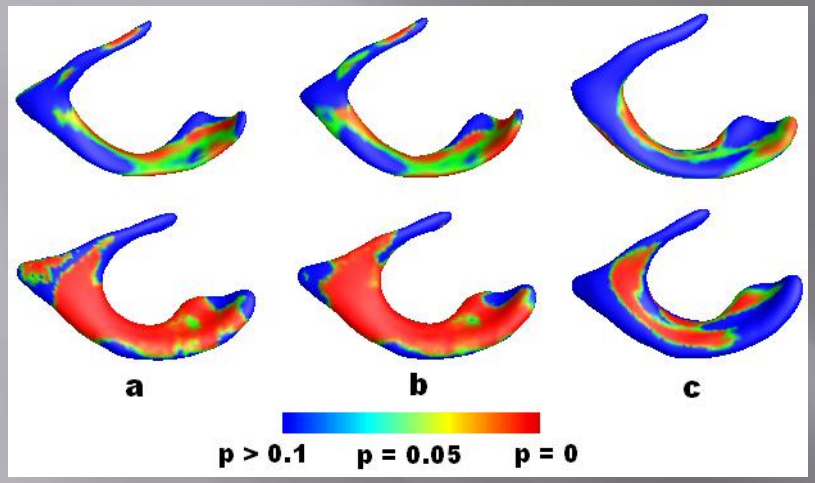
- Register scalar shape features on the sphere while minimizing metric distortion (add area & angle-preserving terms)
- Use 1D aspect of GOF to reduce group-wise registration of thickness to a 1D problem.



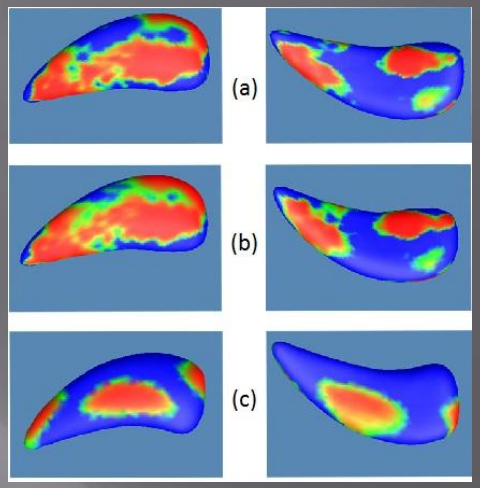


Top: 1D thickness profiles. Bottom: 1D profiles group-registered.

Shape Pipeline Results



P-maps of HIV-NC (top row) and MCI-NC (N~= 600) (bottom row) group difference after registering with (a) group-wise method, (b) unadjusted GOF, (c) SPHARM



Caudate P-maps of AD-NC group difference

	Group	No Group	SPHARM
HIV Vents	**0.00988**	0.01039	0.0149
ADNI Vents	**0.00029**	0.00046	0.0068
ADNI Caudate	**0.00065**	0.0014	0.027

Overall p-values for group differences after 100000 permutations

Thank You