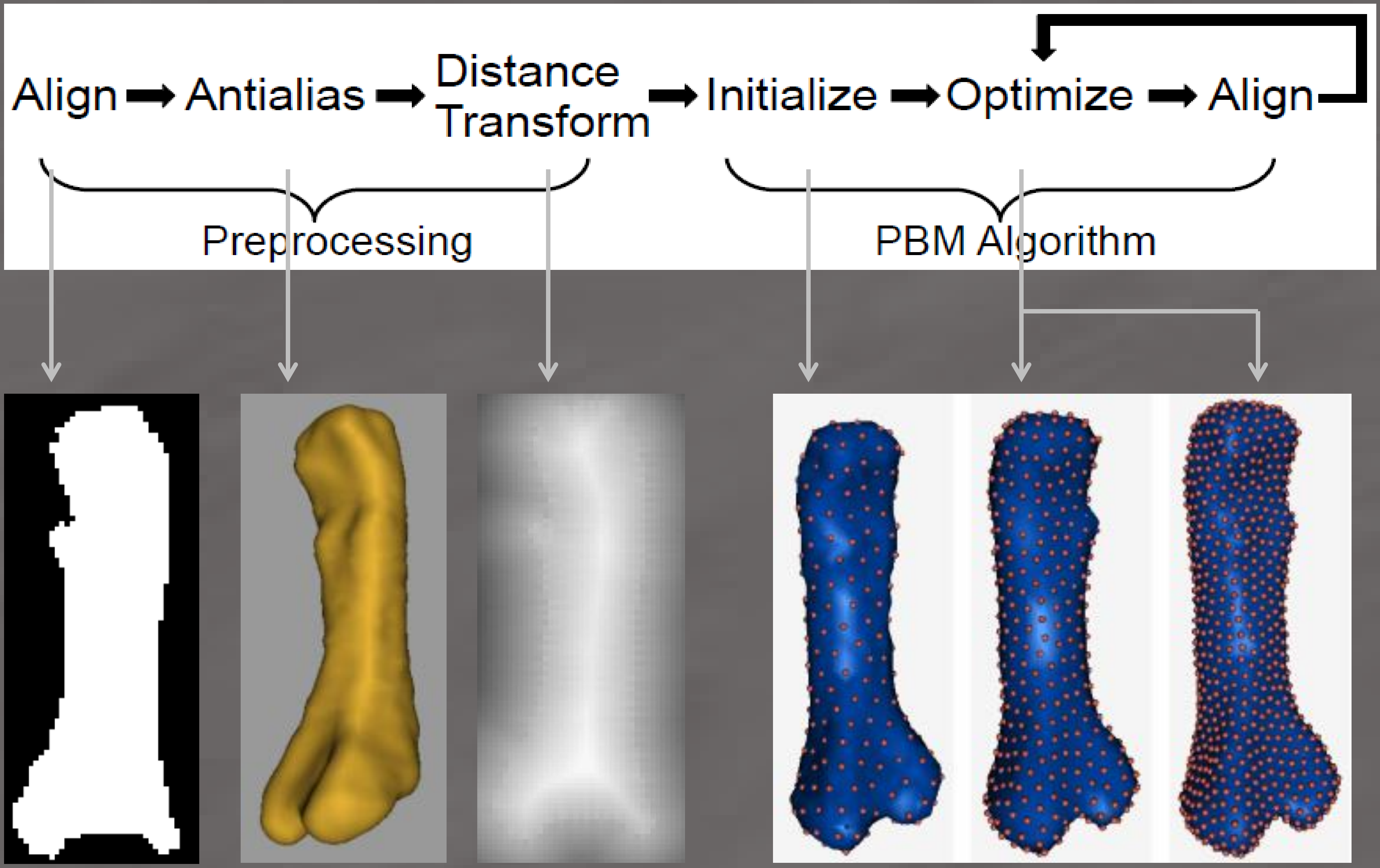
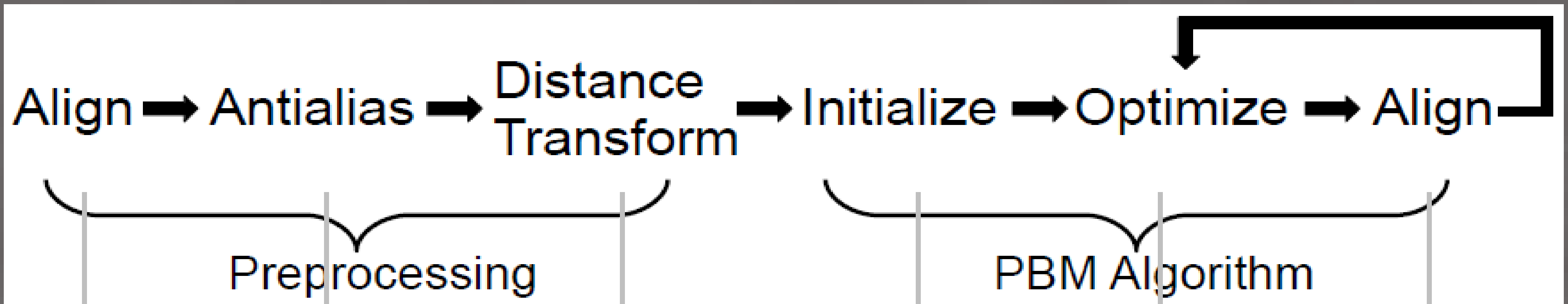
ShapeWorks

The tutorial

Correspondence Pipeline



Command Line Tools



Seg3D/ITK

ShapeWorksGroom

ShapeWorksRun

Analysis: PCA, Group differences → ShapeWorksView

ShapeWorksGroom

Command line collection of preprocessing filters

Syntax

```
ShapeWorksGroom torus.preprocess1.params isolate hole_fill center auto_crop
```

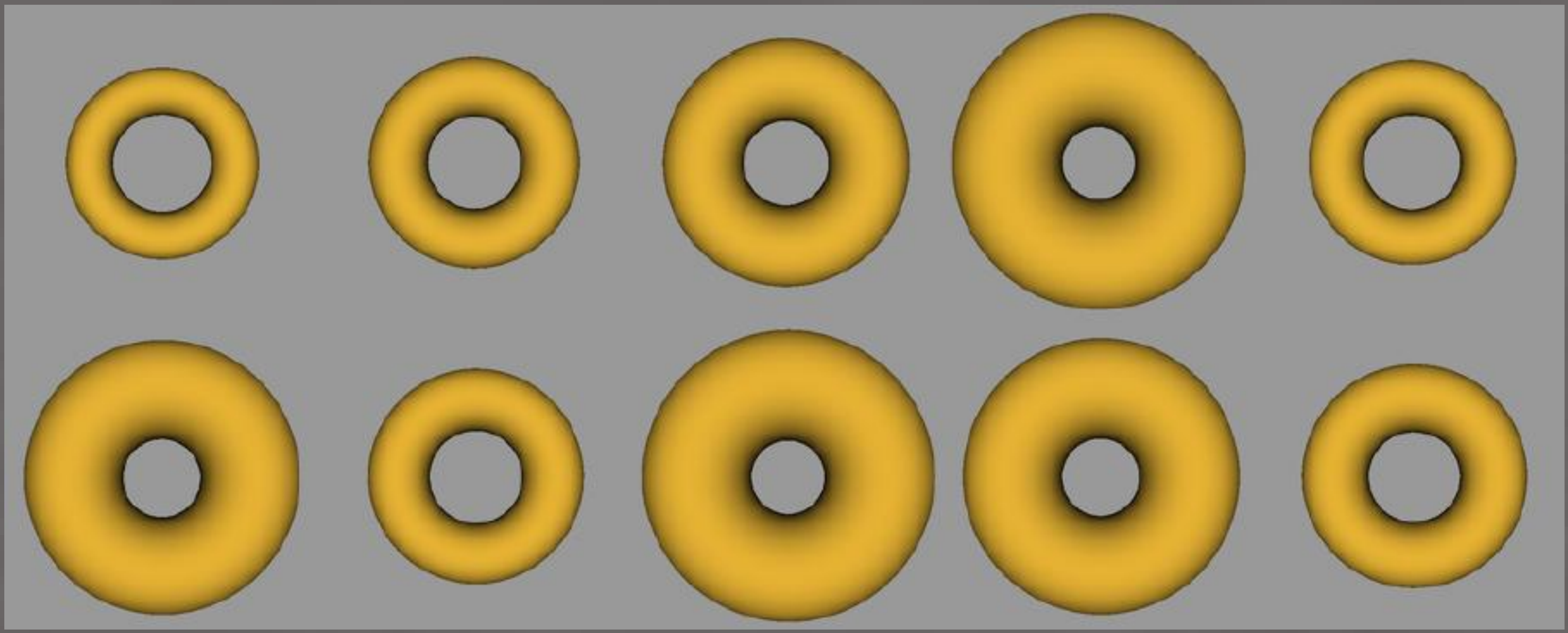
```
ShapeWorksGroom torus.preprocess2.params antialias fastmarching blur
```

Basic filters available

- isolate
- hole_fill
- antialias
- fastmarching
- blur

DEMO: torus example

ShapeWorksGroom



Example tori shapes from population parameterized by *r* and *R*

ShapeWorksRun

Command line tool to initialize and optimize particle positions on shapes in the ensemble

Syntax

```
ShapeWorksRun torus.correspondence.params
```

Notable parameters

- # particles
- adaptivity
- alignment

DEMO: torus example

ShapeWorksRun

Correspondences overlaid on 3 of the input shapes

ShapeWorksView

GUI to visualize correspondences and perform statistical analysis

Syntax

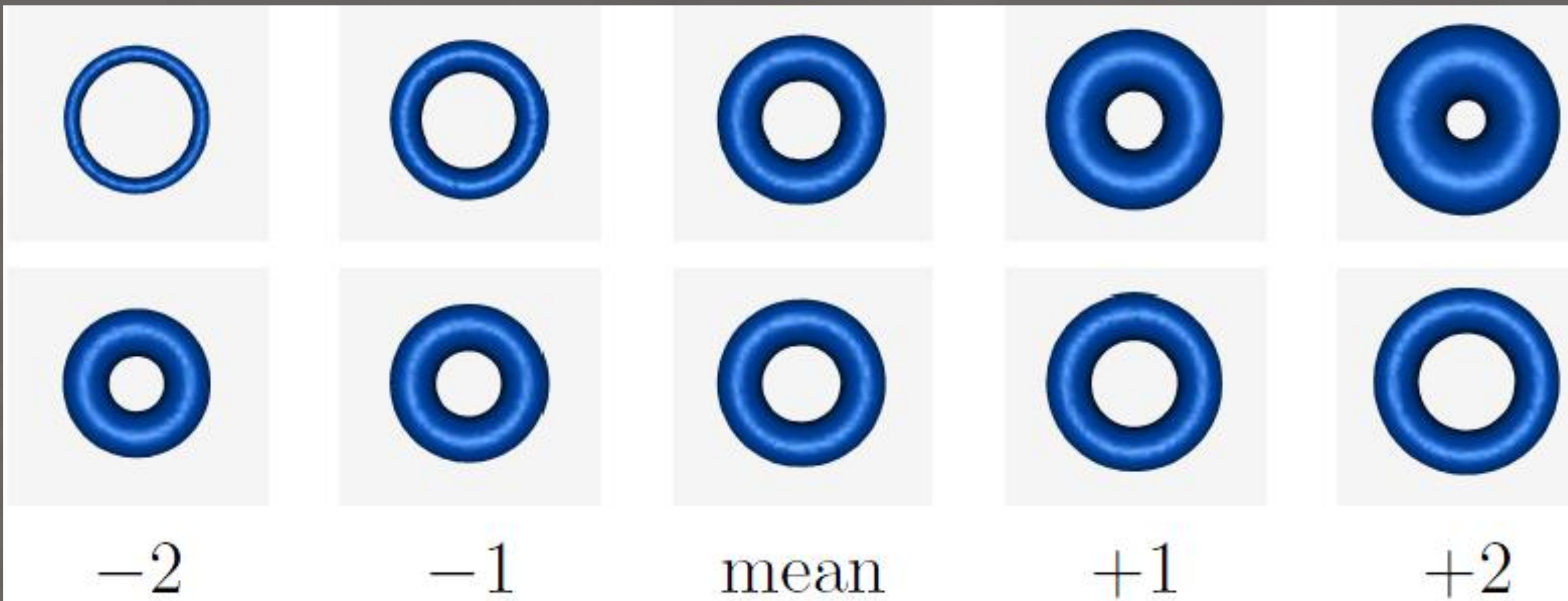
```
ShapeWorksView torus.analyze.params
```

Notable parameters

- Reconstructed shapes
- Modes of variation
- Group differences (not in demo, only if 2 populations are available)

DEMO: torus example

ShapeWorksView



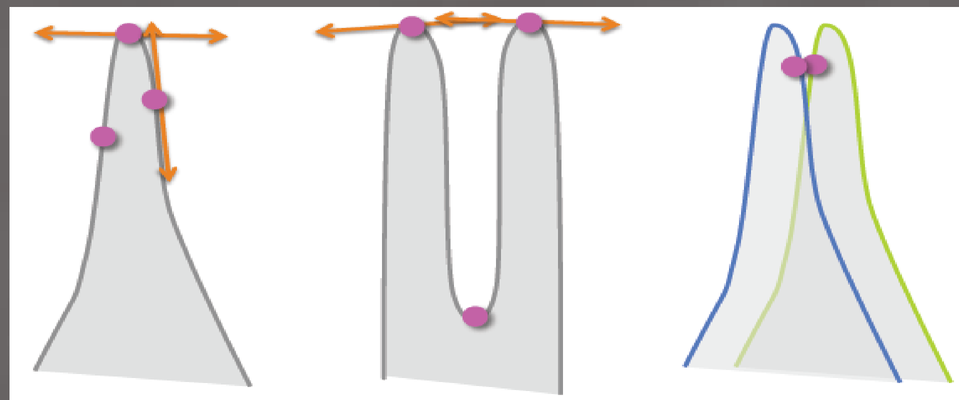
Modes of variation captured by the correspondence model.

The first (top) and second (bottom) modes capture the shape variation consistent with the generative model

Recent Work[†]

[†] M Datar, Y Gur, B Paniagua, MA Styner, RT Whitaker, "Geometric Correspondence for Ensembles of Nonregular Shapes," MICCAI 2011

Challenges of Nonregular Shapes



(a) (b) (c)

Fig: Incorrect correspondences near sharp features when (a) points with different tangent spaces interact, (b) nearby points sampling different parts of the surface interact, (c) optimization is based only on point positions on different shapes

- Geodesic distances
  - computed using intermediate triangular meshes
  - pre-computed between vertices [Fu, et. al†]
  - otherwise computed using two-layered Barycentric interpolation
- Surface normal entropy
  - penalize divergence from "mean" in the space of surface normals
  - helps disambiguate correspondences near convoluted features

† Fu, Z., Kirby, M., Whitaker, R.: A fast iterative method for solving the eikonal equation on triangulated meshes. SIAM Journal on Scientific Computing (2011) To appear

Group Comparison: LV wall†

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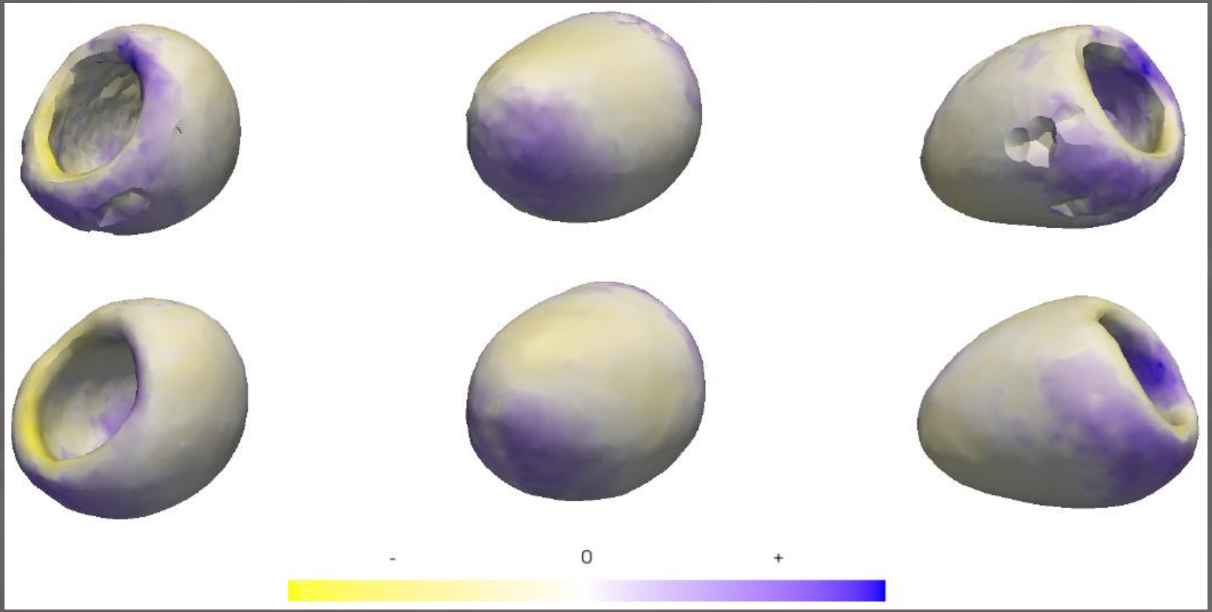
Institute for Computational Medicine, The Johns Hopkins University



Mean differences between normal and ischemic groups (blue => expansion, yellow => contraction)
Top: PBM*, Bottom: proposed method

- Study shape differences between normal and ischemic LV wall segmented at end diastole (ED)
- Results
  - Group mean differences significant with *p-value* < 0.01
  - Shape changes spatially consistent with previously published results

†M Datar, Y Gur, B Paniagua, MA Styner, RT Whitaker, "Geometric Correspondence for Ensembles of Nonregular Shapes," MICCAI 2011

Nonlinear Growth Model

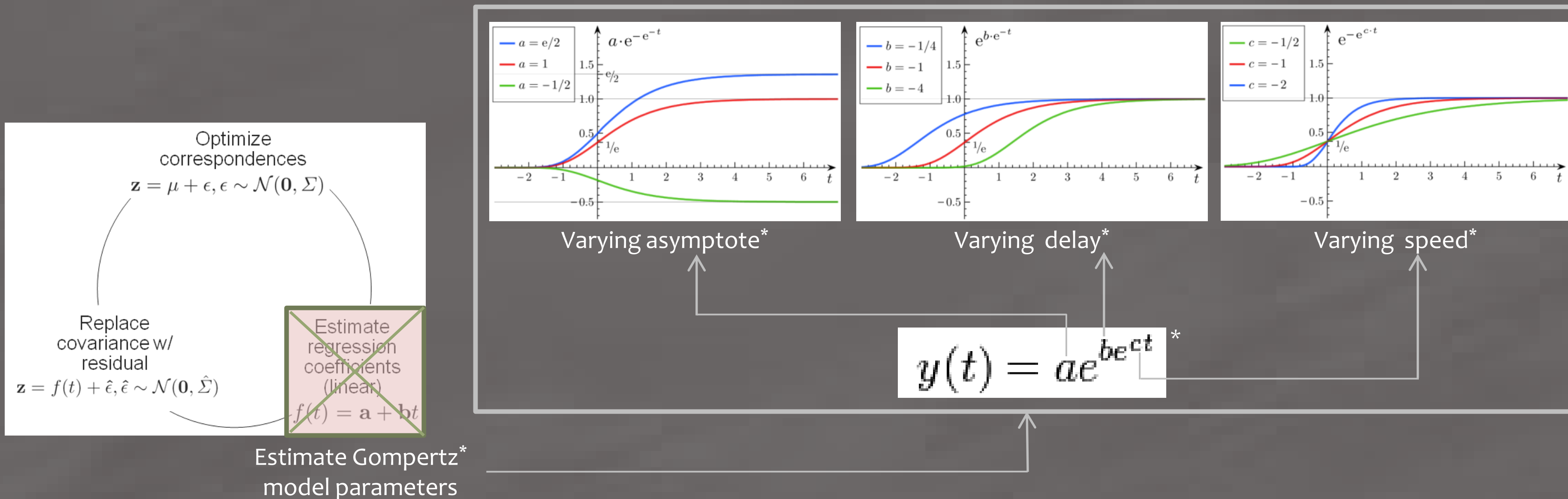


Fig: Replacing linear regression model with nonlinear Gompertz model for optimization

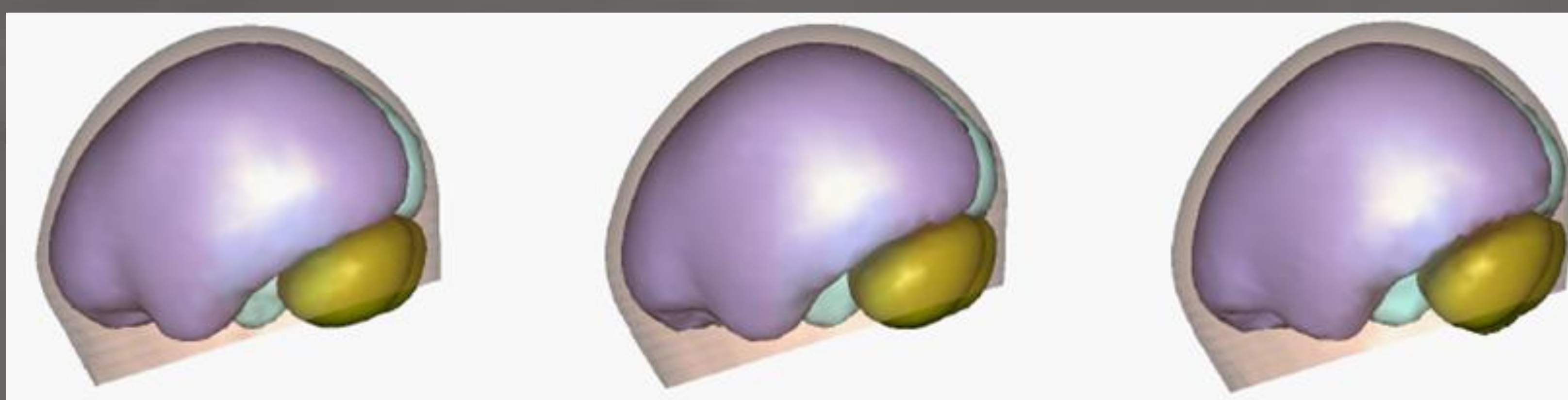
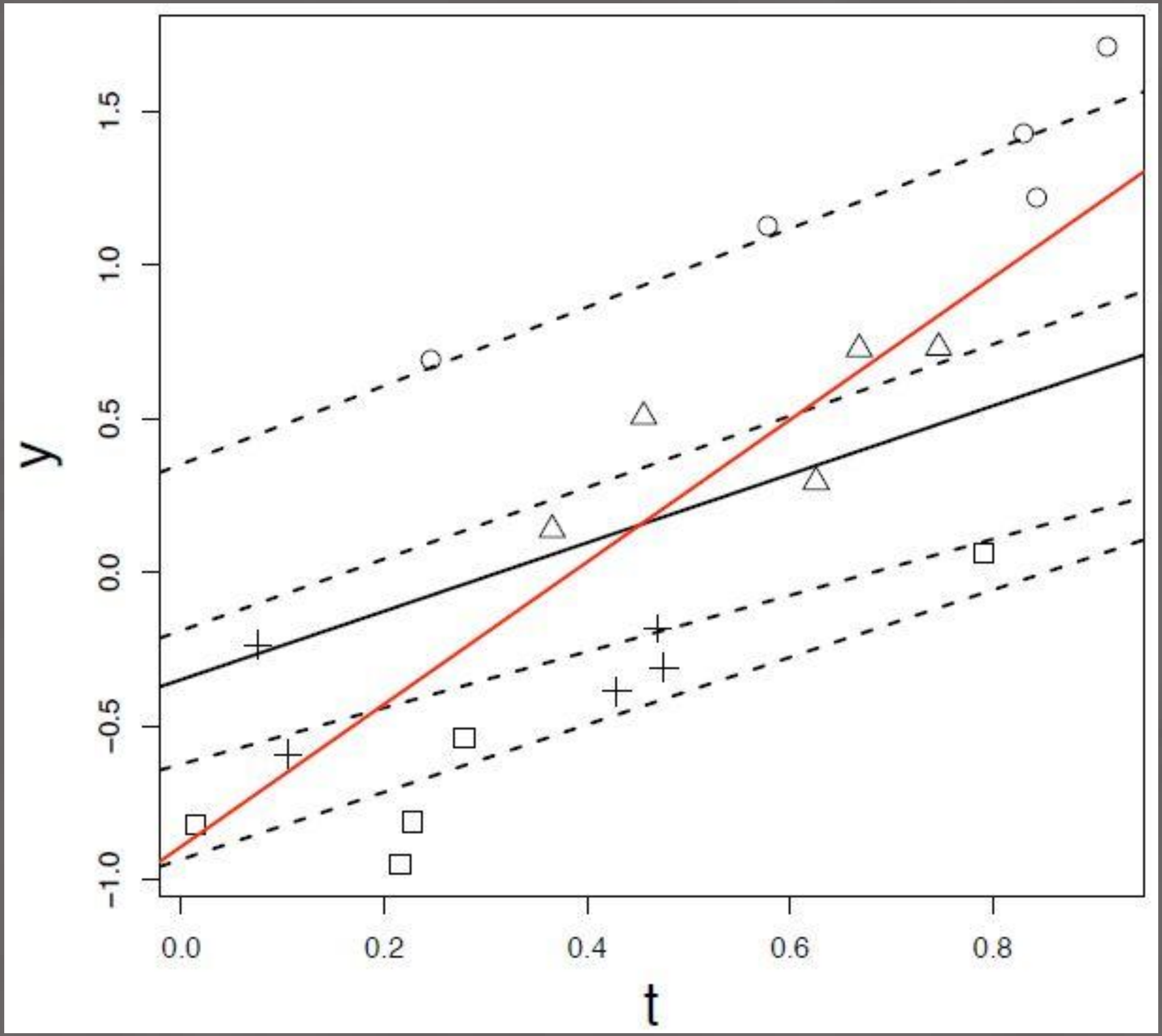


Fig: Progression of growth at three time-points from neonate – 4 years

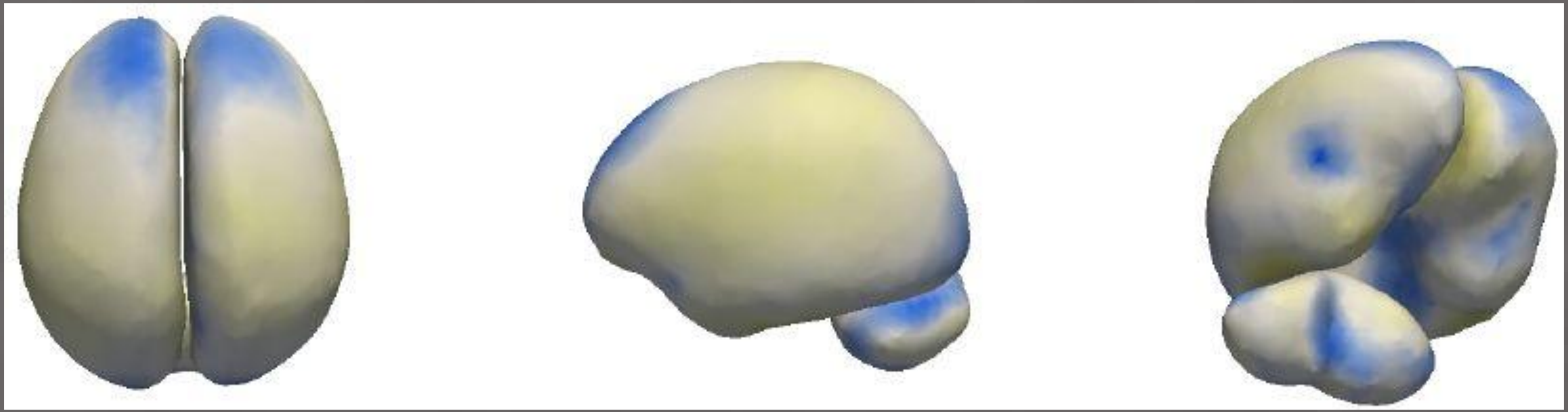
* Wikipedia: Gompertz Function, URL: http://en.wikipedia.org/w/index.php?title=Gompertz_function&oldid=462307381

Mixed Effects Model

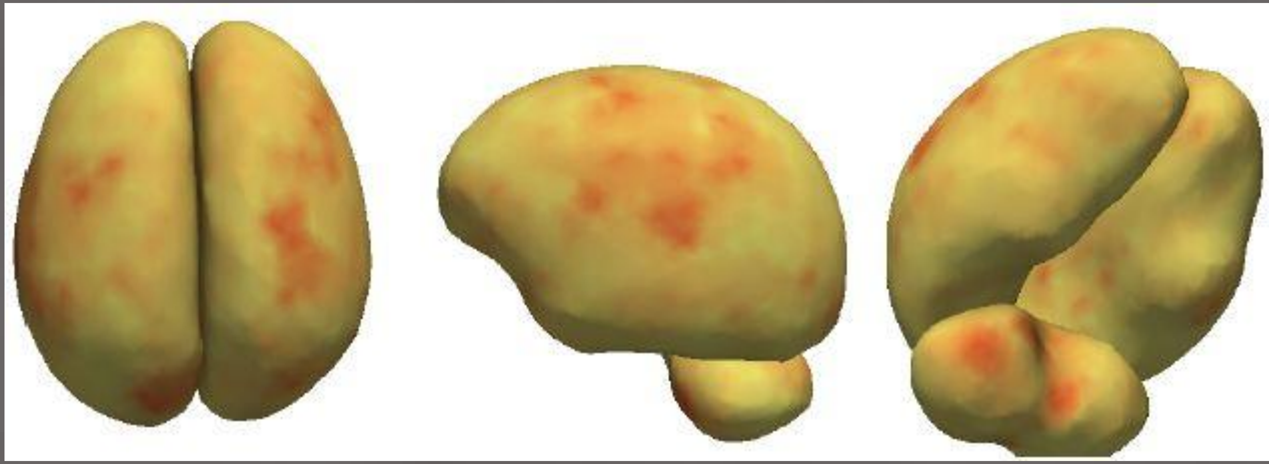


†M Datar, P Muralidharan, A Kumar, S Gouttard, J Piven, G Gerig, RT Whitaker, PT Fletcher, "Mixed-Effects Shape Models for Estimating Longitudinal Changes in Anatomy," STIA 2012

Mixed Effects Model: Trends



Group trend



Individual trend

[†]M Datar, P Muralidharan, A Kumar, S Gouttard, J Piven, G Gerig, RT Whitaker, PT Fletcher, "Mixed-Effects Shape Models for Estimating Longitudinal Changes in Anatomy," STIA 2012

Pairwise Distance Features

Pairwise interparticle distance (Euclidean/Geodesic) as a feature for correspondence optimization

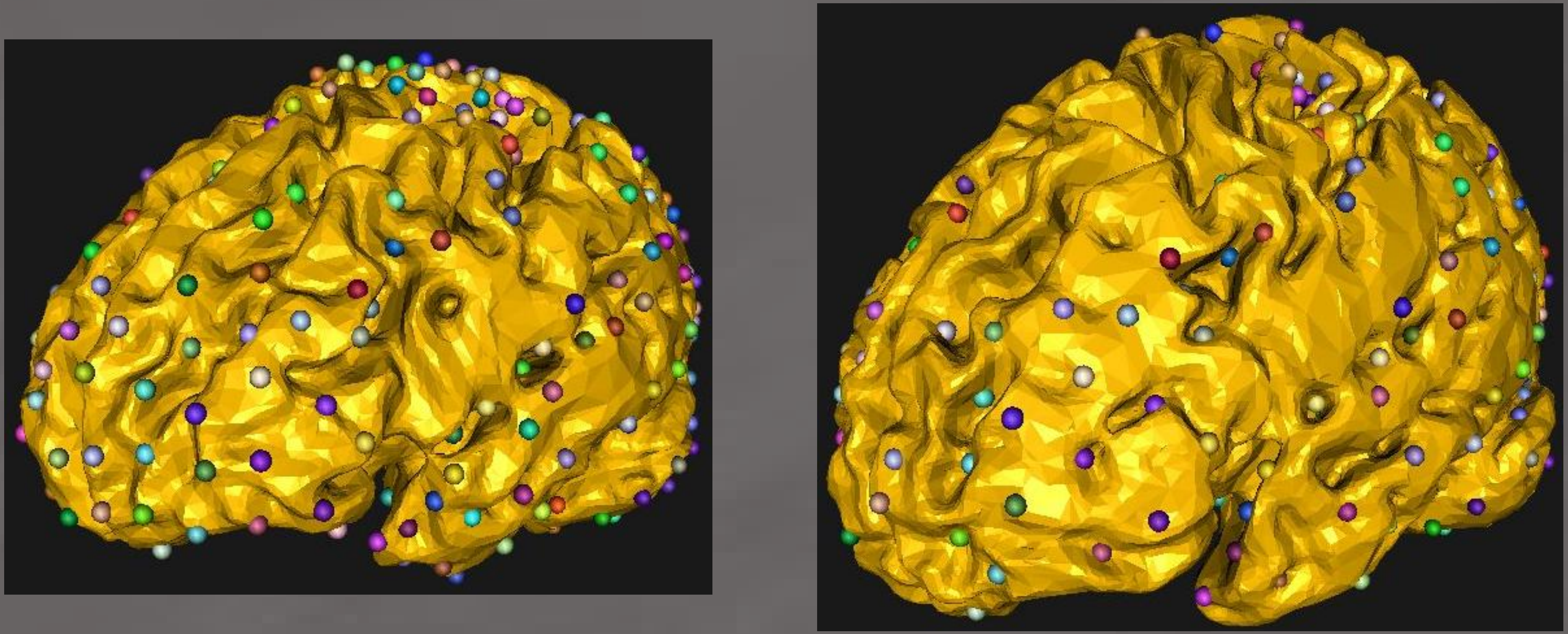


Fig: Initial results from study of cortext shapes. Two examples from the population with correspondences overlaid.
Note that correspondences are not good near the top of the cortex, suggesting the need for additional features (e.g. curvature) to be included

Thank you !

Questions ?