

Modeling Anatomical Variability in Populations

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Biomedical Image Analysis (MRI or CT)

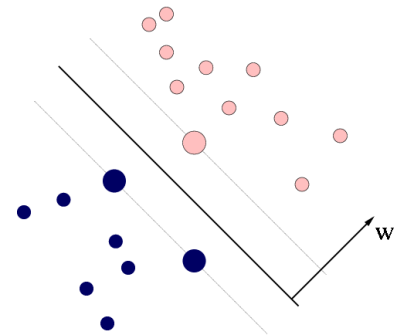
- Compared to Computer Vision:
 - More constrained problem, defined metrics of success
 - Understanding and interpretation
 - » Population studies vs. patient-specific predictions
- Examples:
 - Image segmentation
 - » Well defined organ/tissue, goal: match or exceed expert
 - Image registration/matching
 - » Metric: how well it supports localization
 - fMRI analysis
 - » How well the model predicts behavior

Common solutions

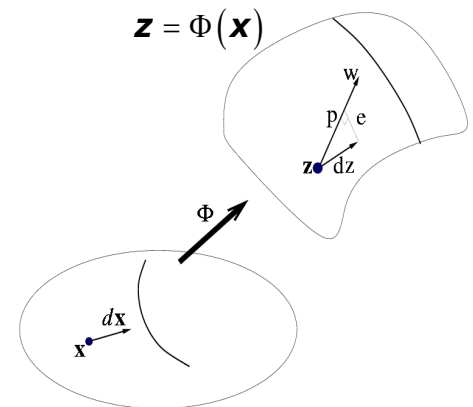
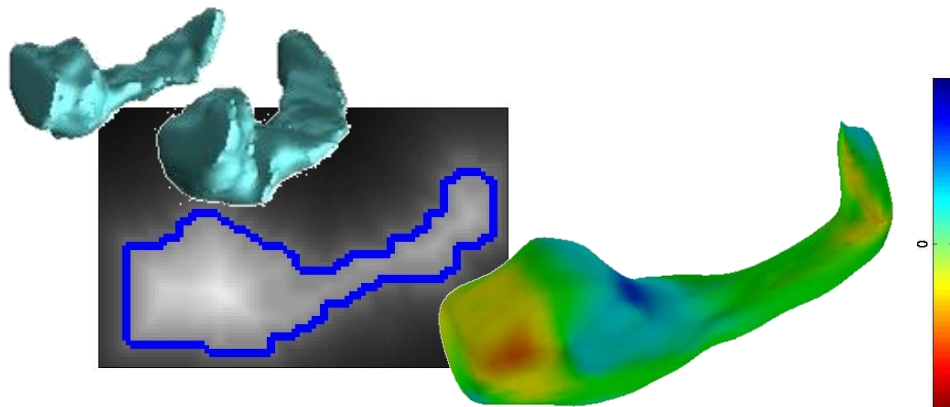
- Geometry and Statistics
 - Geometric transformations
 - » real deformation and capture variability
 - Probabilistic generative models
 - » variability of images (MRI, CT) and signals (fMRI)
- Examples:
 - Active shape/appearance models (Cootes and Taylor)
 - Mixture models with spatial priors (Wells, Van Leemput)
 - Mutual Information registration (Viola and Wells)
 - Diffeomorphic transformations (Miller, Thirion, Pennec)
 - Hierarchical models (Friston, Penny, Worsley, Genovese, Wells)
- Outstanding challenges
 - Patient-specific predictions
 - Anatomical variability

Anatomical Shape Analysis

- Image-based descriptors of shape
- Model of differences between two populations
 - Discriminative modeling
- Explicit representation of differences
 - Perturbation analysis



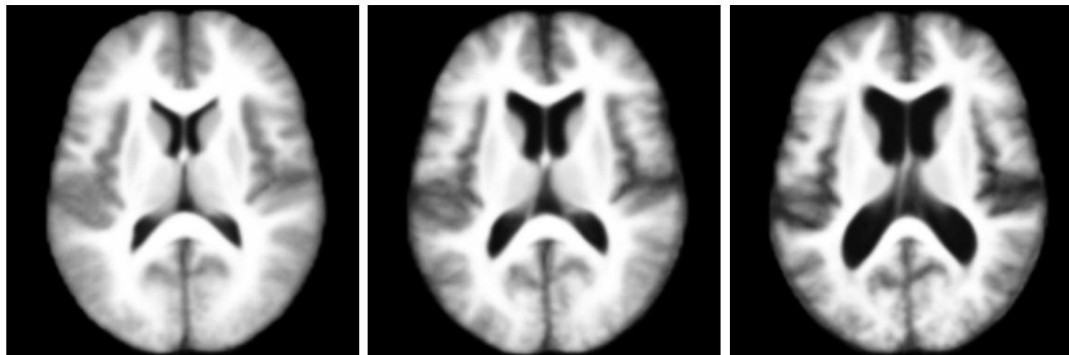
Hippocampal shape in schizophrenia



Anatomical Heterogeneity

- Population as a collection of homogeneous sub-groups
 - Correlate clinical and demographic information with the partition
- Mixture model
 - Clustering of subjects into sub-populations
 - Average template for each sub-population
 - Simultaneously estimate the partition and the templates
 - » Generalized EM algorithm with image registration

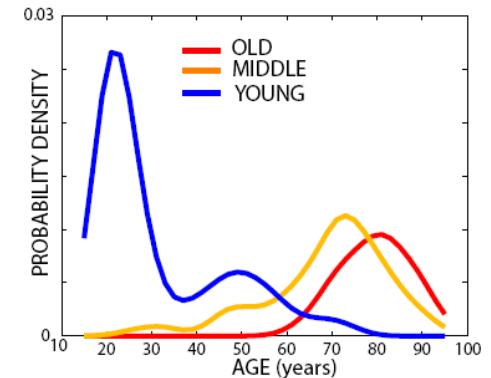
Anatomical templates in aging



Young

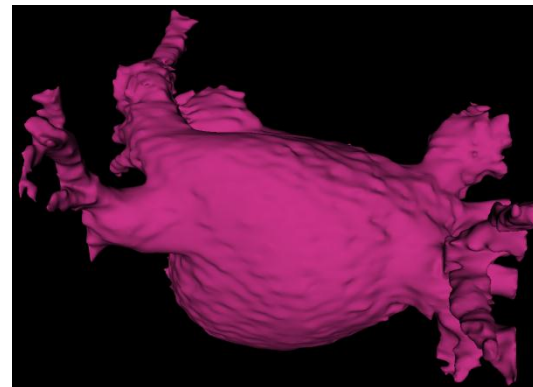
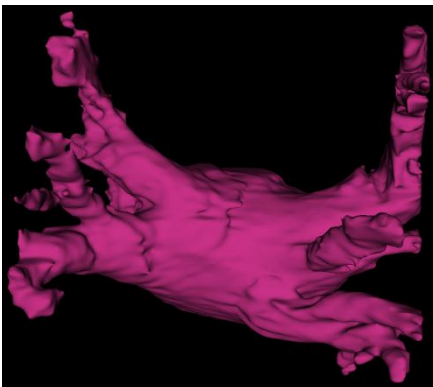
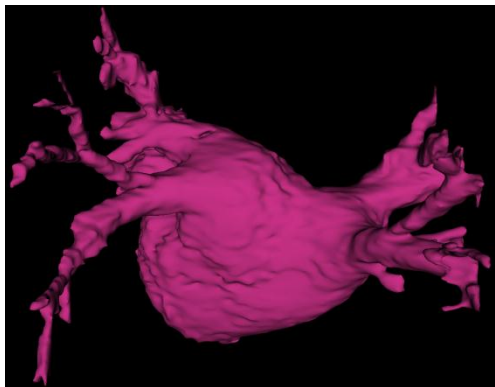
Middle

Old

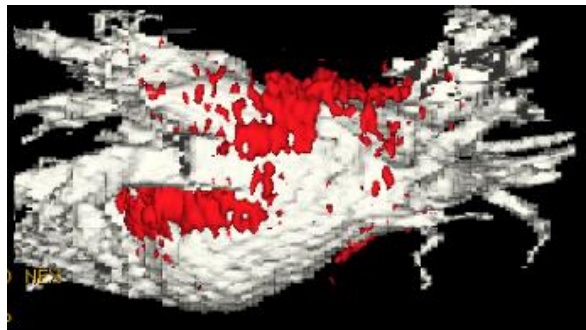
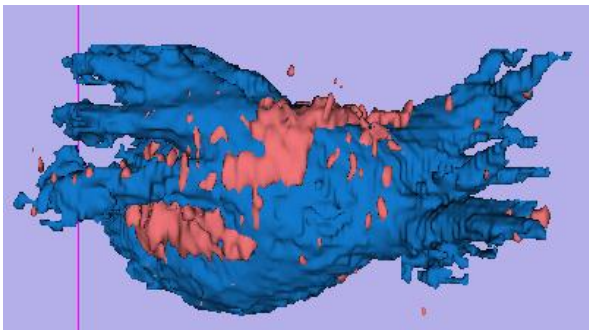


Nonparametric Atlases for Segmentation: Left Atrium

- Left atrium segmentation:



- Spatial prior for ablation scars:



Functional Organization of the Brain

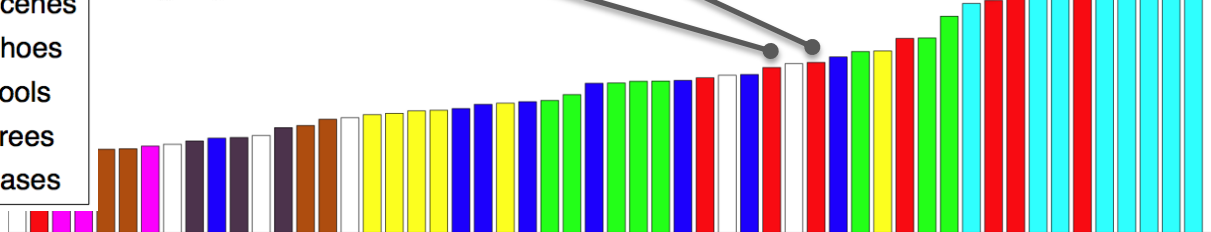
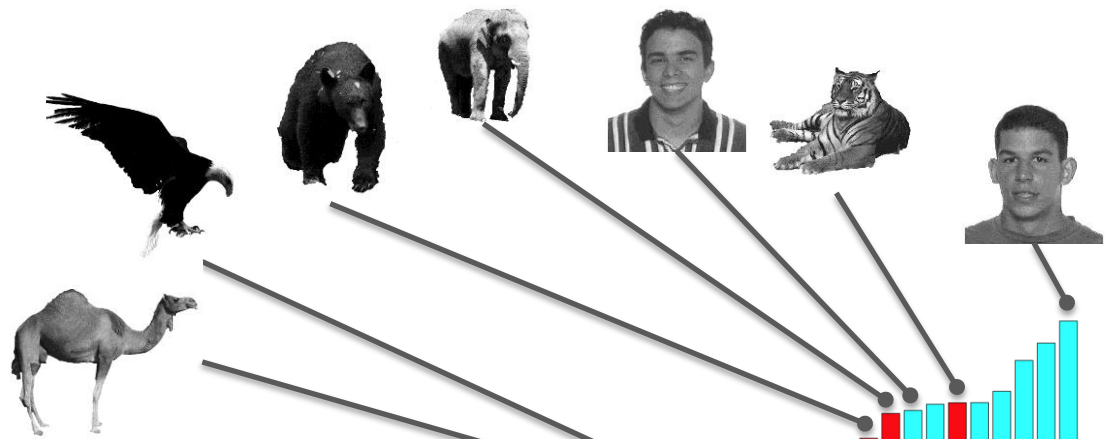
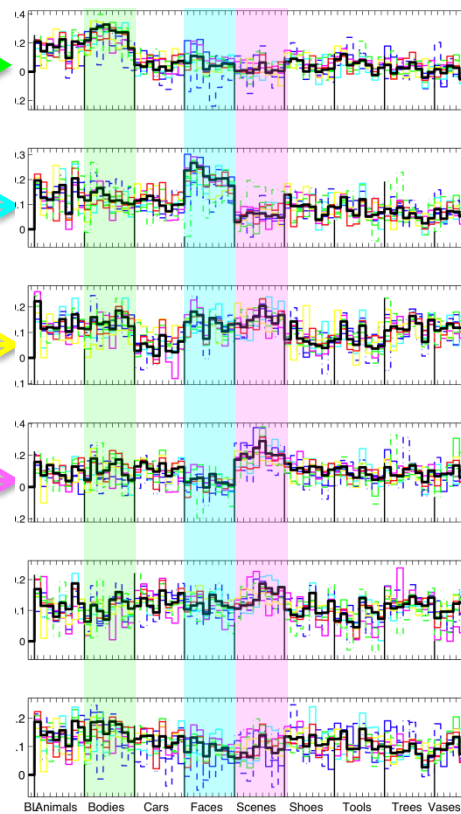
- Cluster functional response profiles
 - Hierarchical model for population
 - Enables discovery of
 - » Novel functional systems
 - » Novel stimulus categories
 - Removes the need for spatial alignment
 - Enables novel fMRI experiments

Body

Face

?

Scene



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CRCNS

NIPS'10,
NeuroImage'10

Lessons Learned

- Not a computer vision problem, but an interesting problem that involves images
 - Need to understand the problem and the goals
 - Work closely with the scientist
- Well defined goals and (at times painful) ways to validate
 - Might change overtime
- Closely related to computer vision, machine learning and probabilistic inference