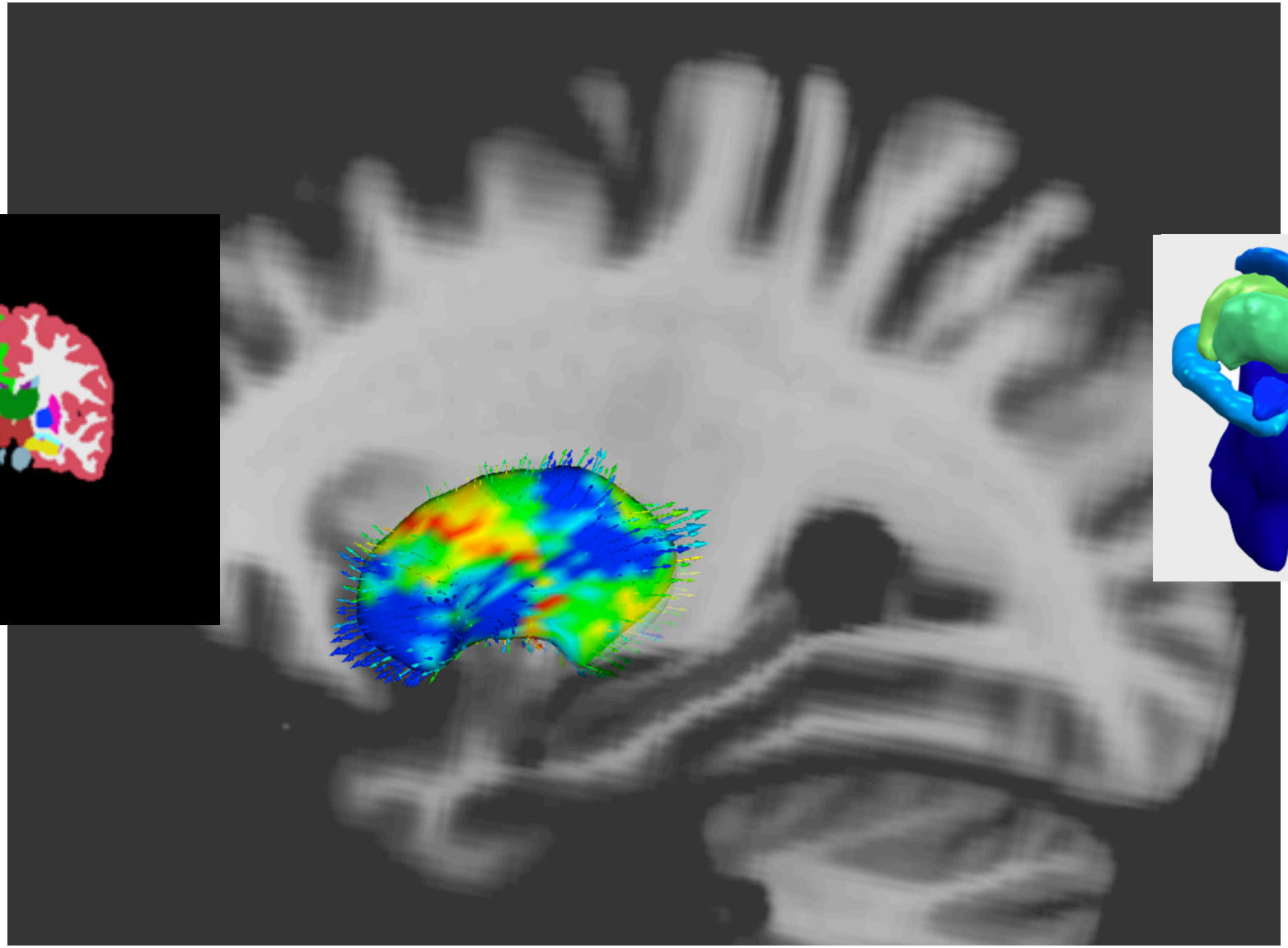
FIRST

FMRIB's Integrated Registration & Segmentation Tool

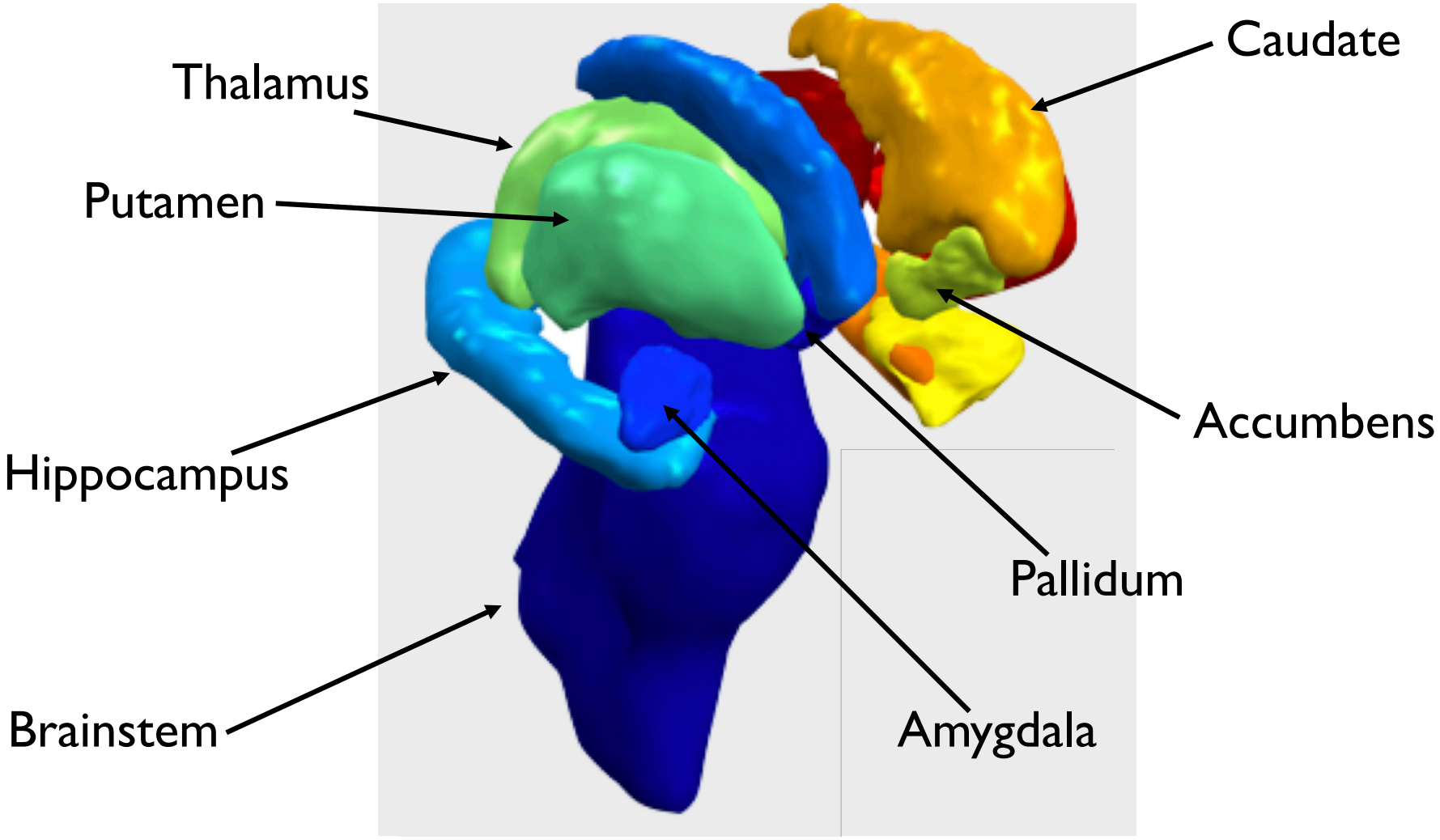
Segmentation of subcortical brain structures



Sub-Cortical Structure Models

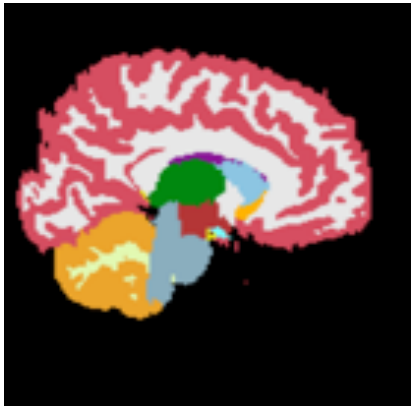
Incorporate prior anatomical information via explicit shape models

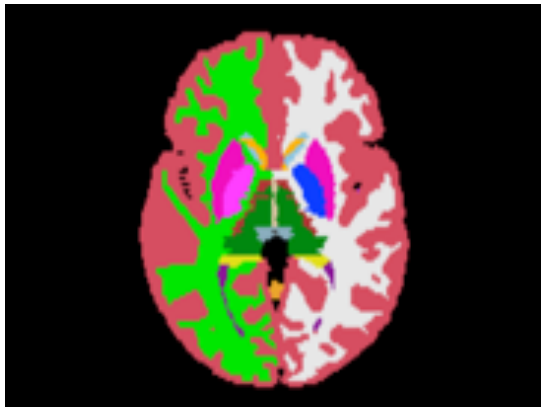
Have 15 different sub-cortical structures (left/right separately)



Training Data

- Manual segmentations courtesy of David Kennedy, Center for Morphometric Analysis (CMA), Boston
- 336 complete data sets
- T_1-weighted images only
- Age range 4 to 87
  - Adults: Ages 18 to 87, Normal, schizophrenia, AD
  - Children: Ages 4 to 18, Normal, ADHD, BP, prenatal cocaine exposure, schizophrenia.

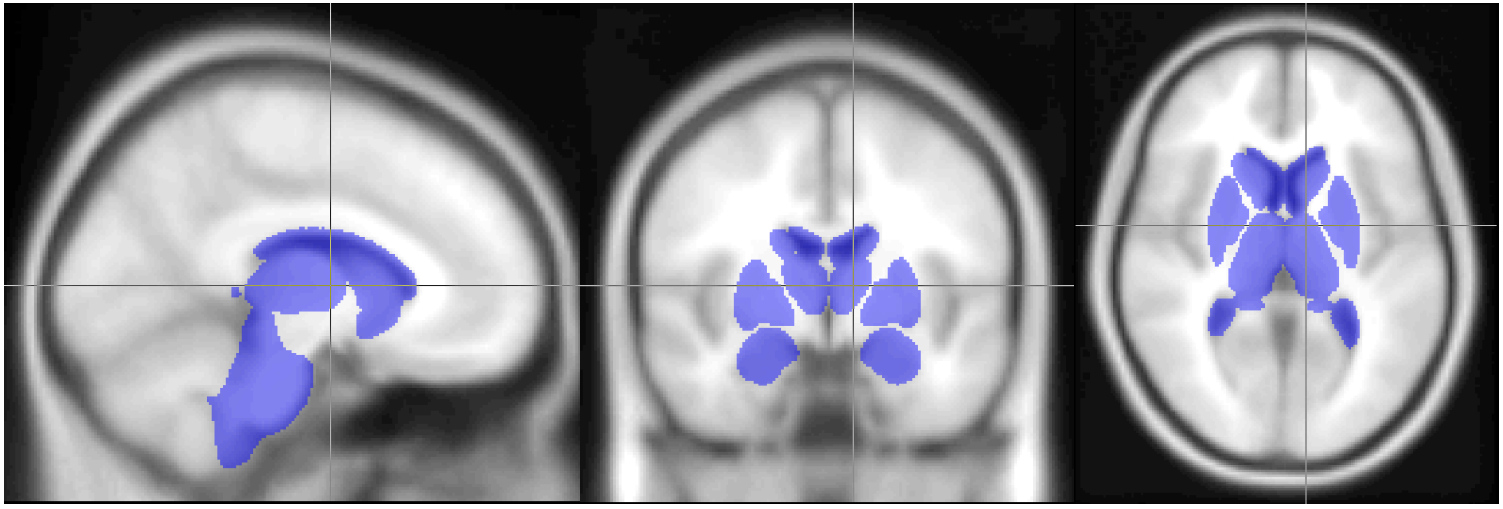




Model Training : Alignment to MNI152 space

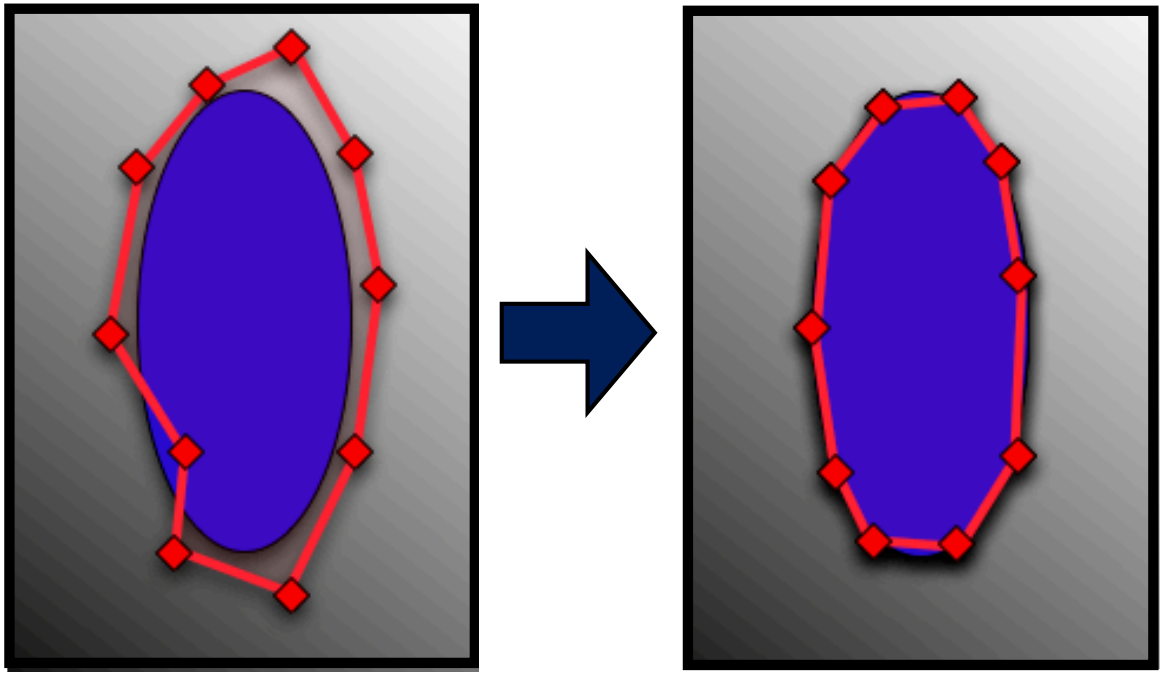
- All CMA data affine-registered to MNI152 space
  - 1mm resolution, using FLIRT

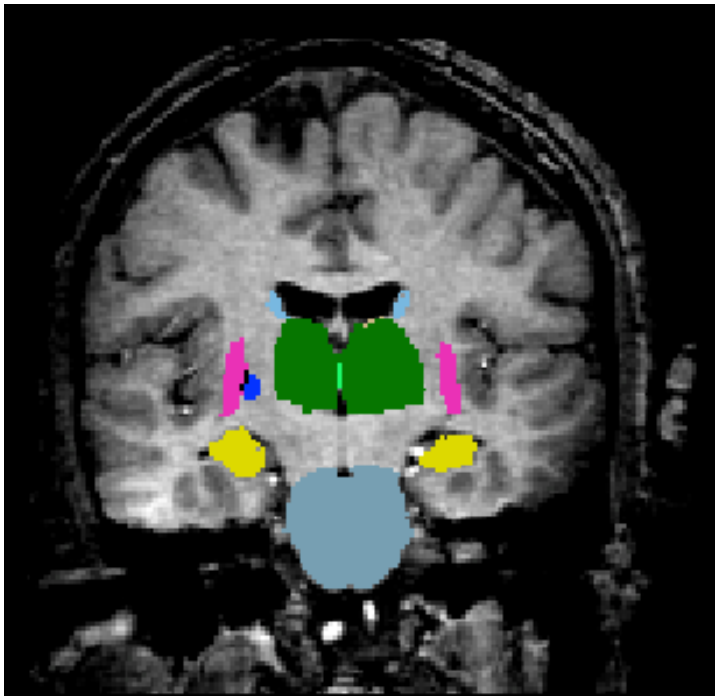
- 2-stage process:
  - Whole head 12 DOF affine
  - 12 DOF affine with MNI-space sub-cortical mask



Deformable Models

- Model: 3D mesh
- Use anatomical info on shape & intensity (from training)
- Deformation: iterative displacement of vertices
- Maintain point (vertex) correspondence across subjects





The Model: Shape

- Model average shape (from vertex locations)
- Also model/learn *likely variations* about this mean
  - modes of variation of the population; c.f. PCA
  - also call eigenvectors
- Average shape and the modes of variation serve as prior information (known before seeing the new image that is to be segmented)
  - formally it uses a Bayesian formulation

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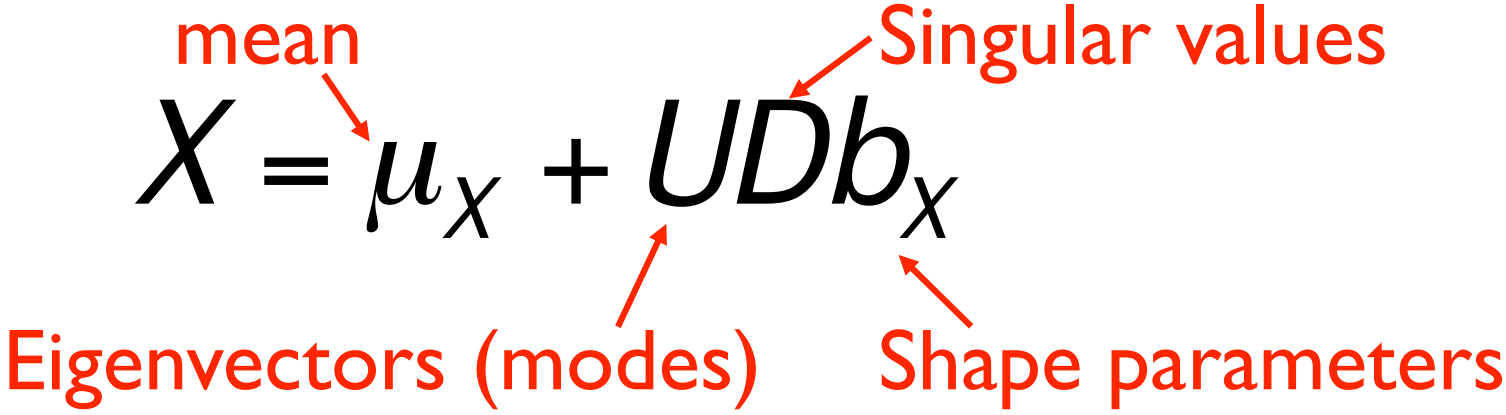
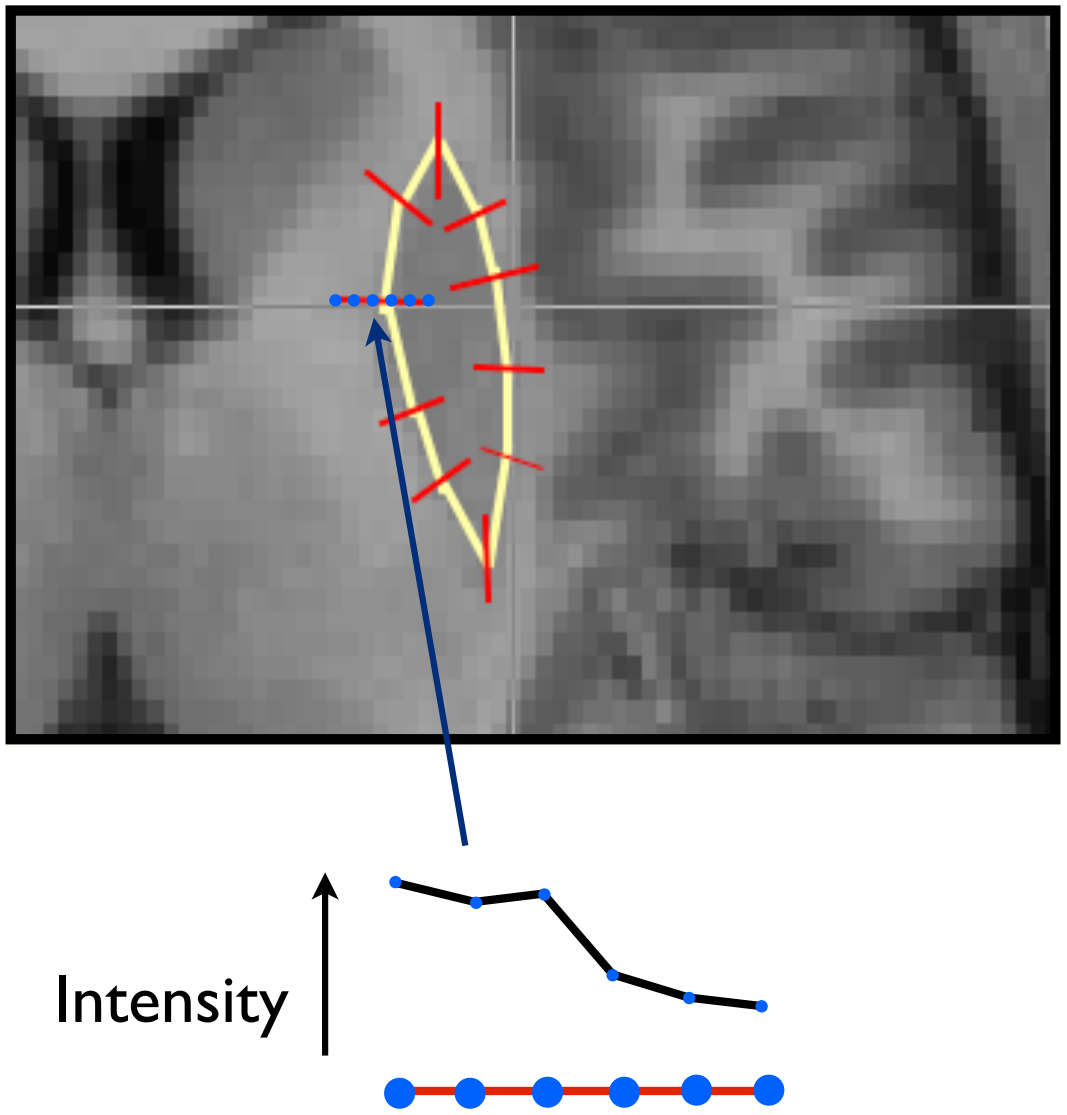


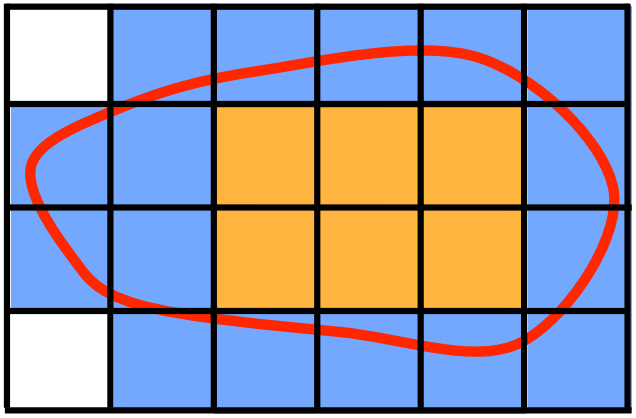
The Model: Intensity

- Intensity is then sampled along the surface normal and stored
- Learn average shape/ intensity and "modes of variation" about both
- Aside: the intensities are re-scaled to a common range and the mode of the intensities in the structure is subtracted



Boundary Correction

- FIRST models all structures by meshes
- Converting from meshes to images gives two types of voxels:
  - boundary voxels
  - interior voxels
- Boundary correction is necessary to decide whether the boundary voxels should belong to the structure or not
- Default correction uses FAST classification method and is run automatically (uncorrected image is also saved)
  - ensures that neighbouring structures do not overlap



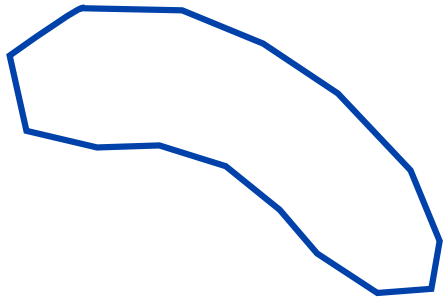
Boundary voxel

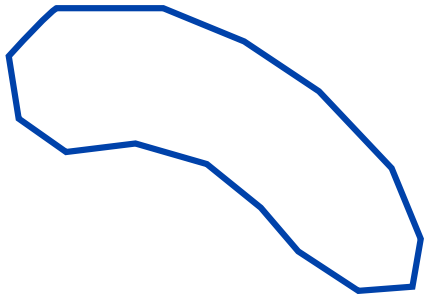
Interior voxel

Vertex Analysis

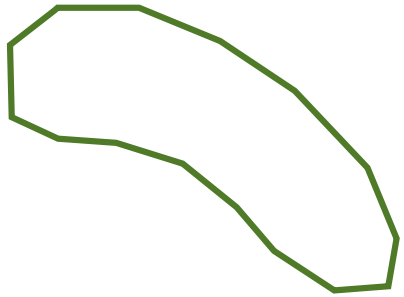
- Use a univariate test at each vertex to measure difference in location (e.g. between means of two groups of subjects)

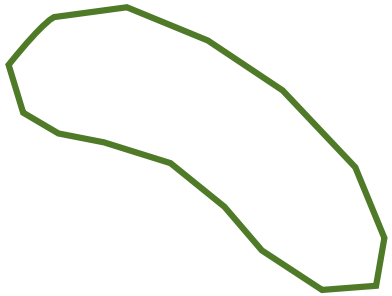
Controls





Disease





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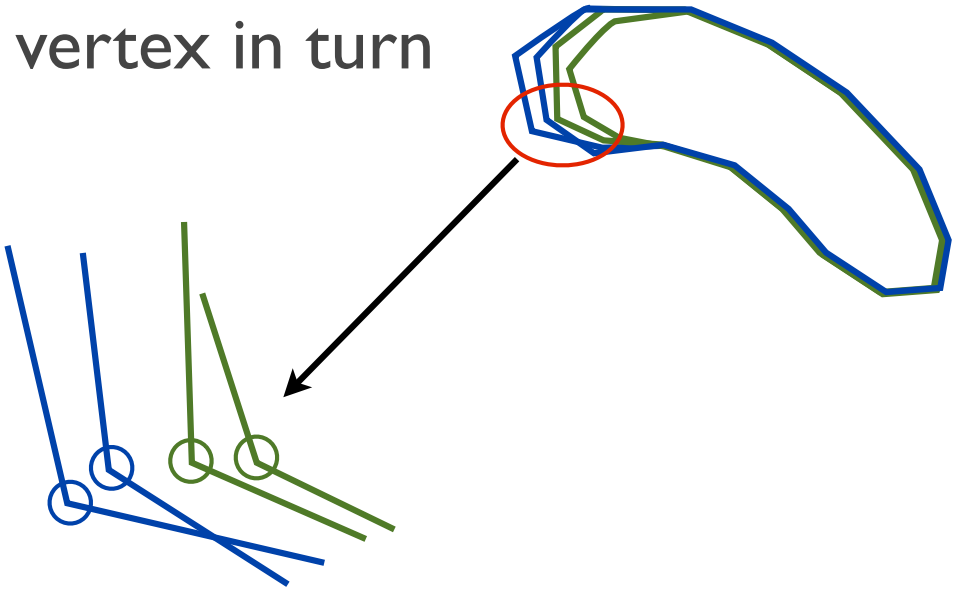
Controls Disease

Consider each vertex in turn



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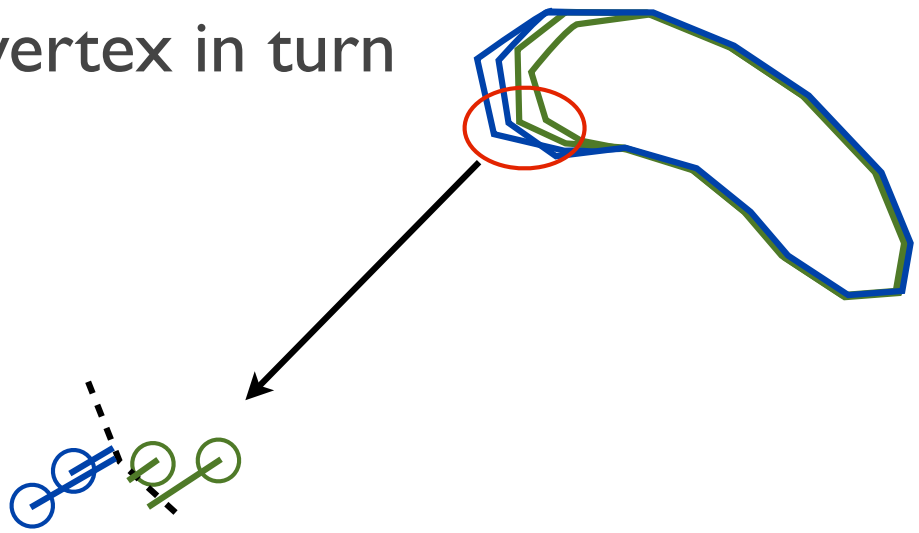


Do a test on distance of these vertices to average shape

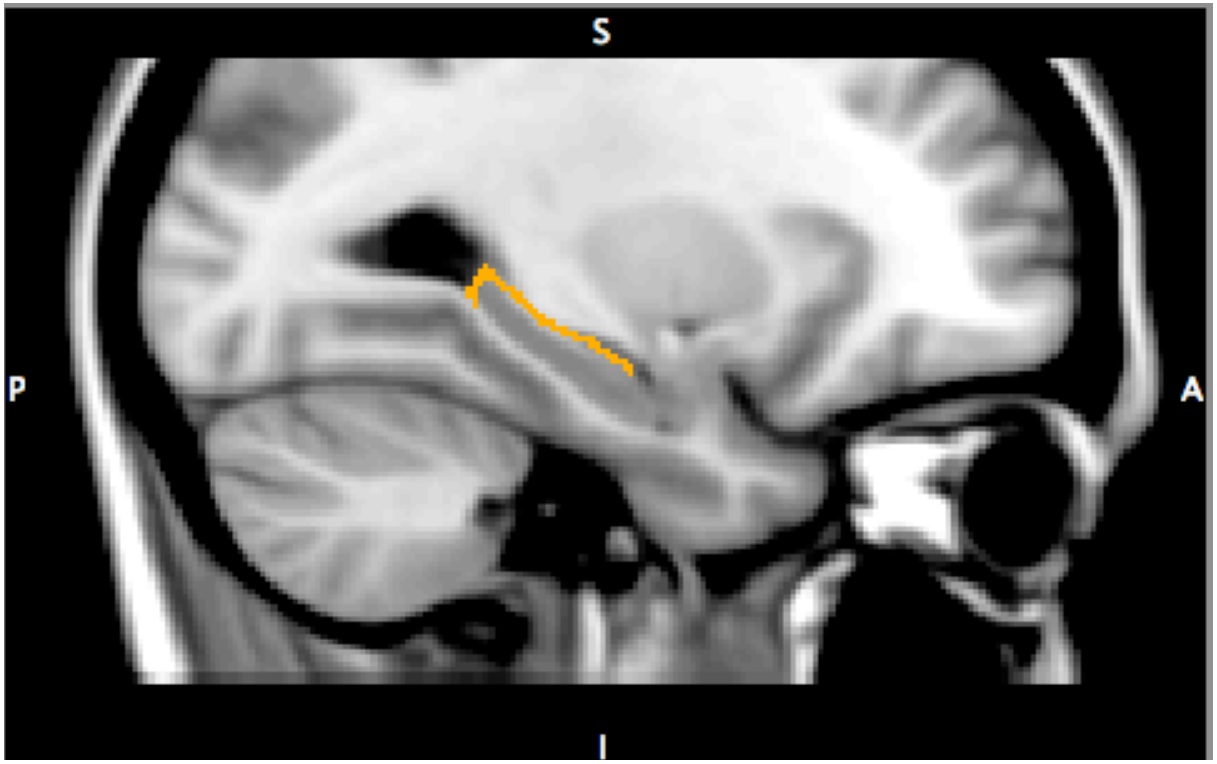
Vertex Analysis

- Use a univariate test at each vertex to measure difference in location (e.g. between means of two groups of subjects) using distance along surface normals

- Results are now given as ***images*** and statistics done with ***randomise***

- Can do analysis in MNI space or native structural space

- MNI space analysis ***normalises for brain size***



Running FIRST

- Inputs:
  - T_1-weighted image
  - Model (built from training data) - provided with FSL

- Applying FIRST
  - A single command: run_first_all
    1. registers image to MNI152 1mm template
    2. fits structure models (meshes) to the image
    3. applies boundary correction (for volumetric output)

- Analysis:
  - Use command: first_utils
    - volumetric analysis (summary over whole structure)
    - vertex analysis (localised change in shape and/or size)
    - randomise (with multiple comparison correction)

FIRST

FMRIB's Integrated Registration & Segmentation Tool

Summary

- Specific to certain deep grey structures
- Uses broad training set - very general demographics
- Can only work with T1-weighted images
- Models average and variations of shape and intensity
- Represents the boundary as a set of points
- Separate boundary correction step to get voxel labels

- Can perform vertex analysis to look at changes in shape and size