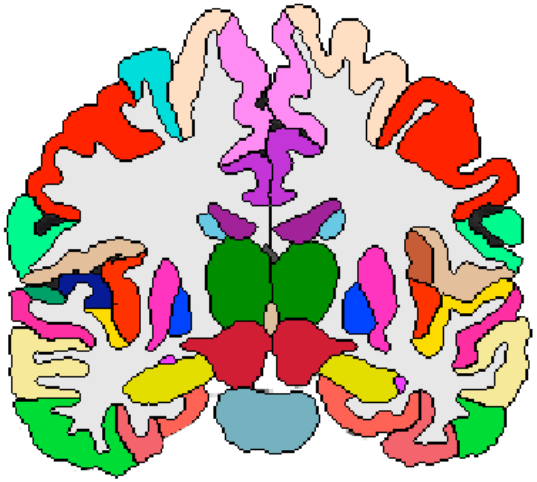
Mindboggle project overview

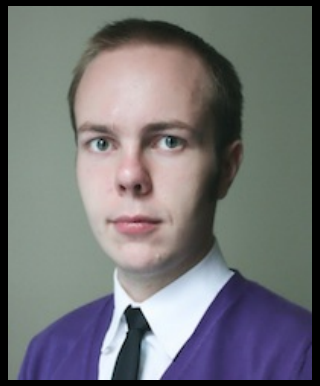
arno klein
arno@binarybottle.com
asst. professor of clinical neurobiology
columbia university



April 29, 2011
LabGab

Forrest Bao (Texas Tech)
Anatomical feature extraction

Noah Lee
Alt. features (spectral, machine learning)
Graph-based feature database



Yrjö Häme
Feature matching

Denis Peruzzo
Feature graph matching
DTI tractography

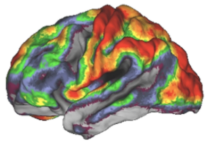
Mireia Montanola (intern)
Surface parametrization

Brian Avants (UPenn)
Diffeomorphic registration

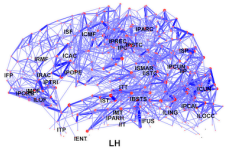
How should we label brains?

1. Manual labeling

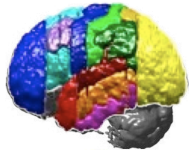
2. Functional mapping



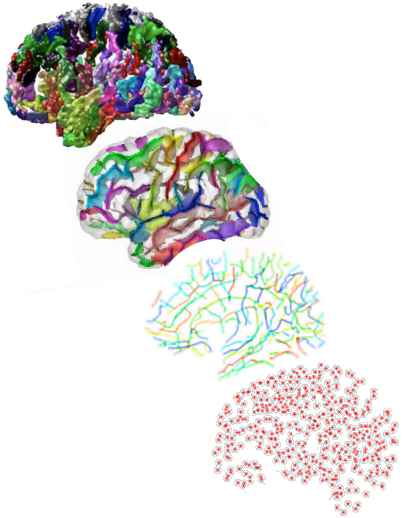
3. Tractography-based segmentation



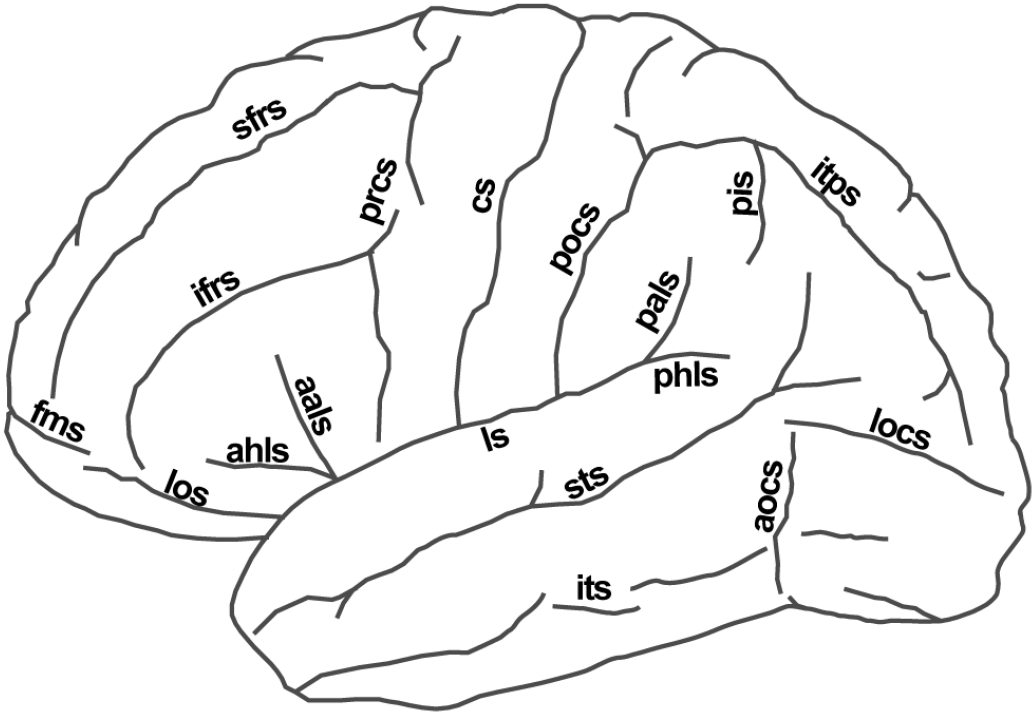
4. Registration-based labeling



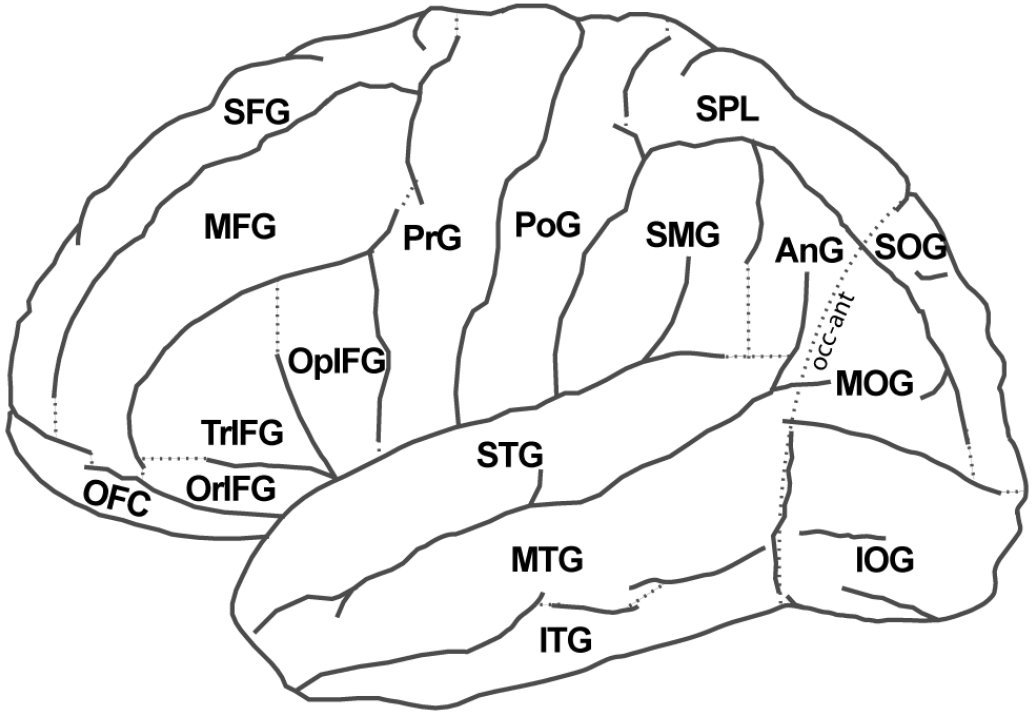
5. Feature matching



Sulcus definitions

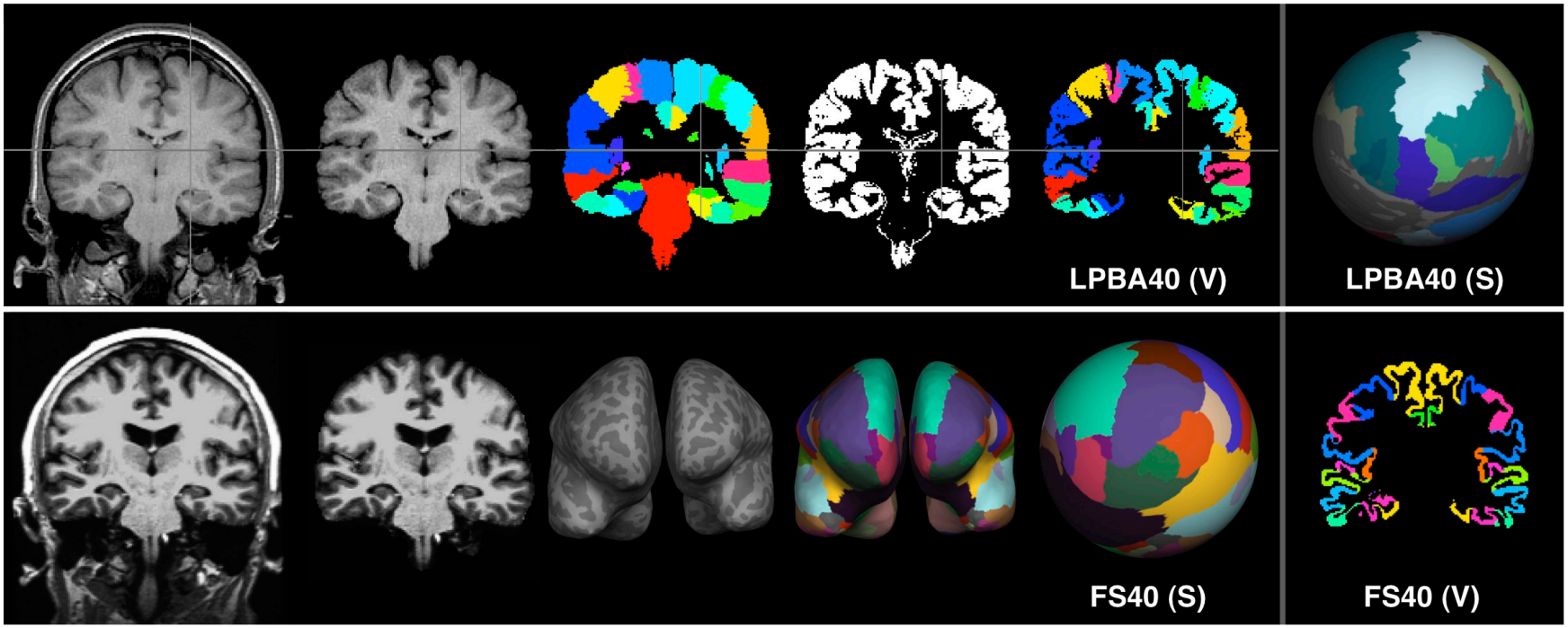


Gyrus definitions



Volume and surface data

(labeled in volumes ***and*** surfaces)



How should we label brains?

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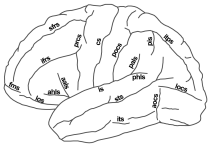
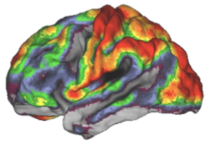
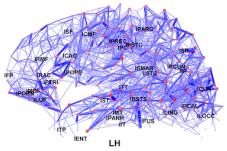


2. Functional mapping



3. Tractography-based segmentation



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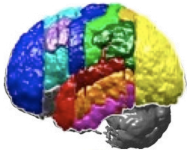
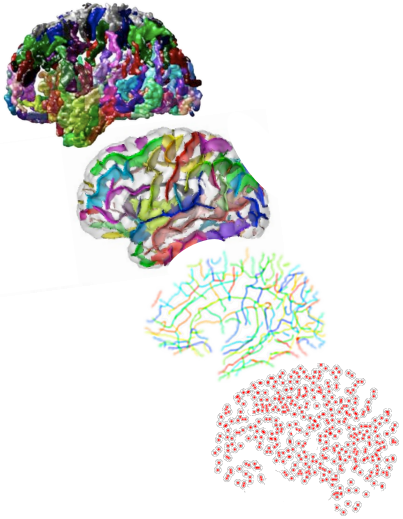
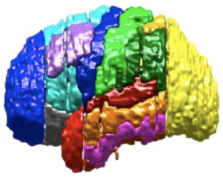


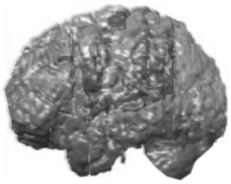
5. Feature matching



4. Registration-based labeling

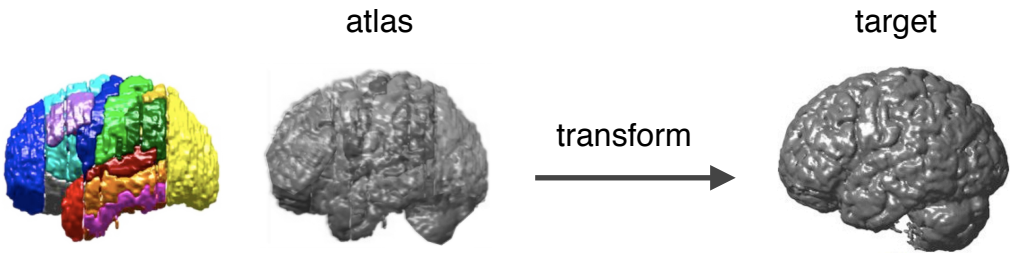
atlas



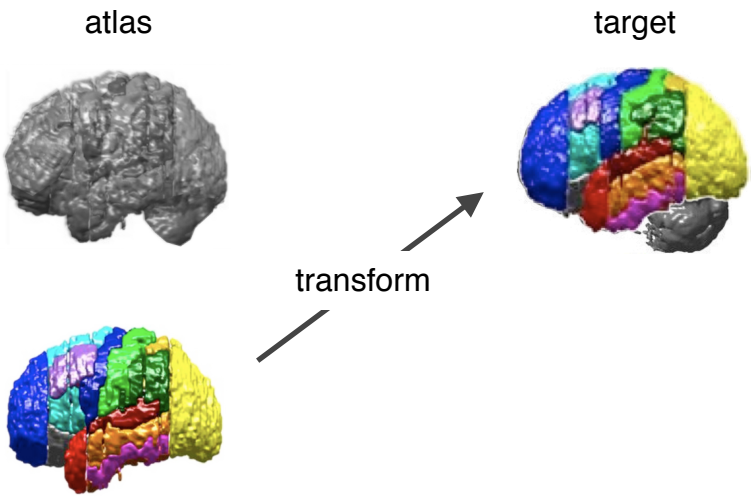


target

Step 1: compute the registration transform from the atlas to the target



Step 2: apply the transform to the atlas labels



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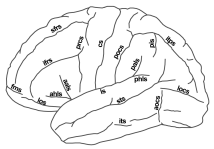

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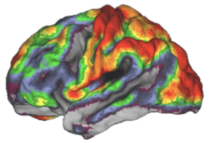

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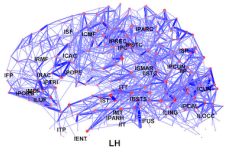

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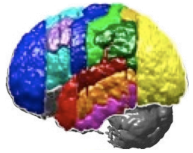
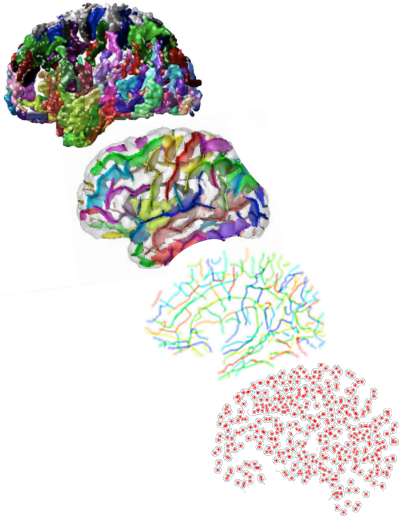
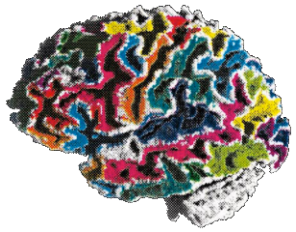


- 5. Feature matching

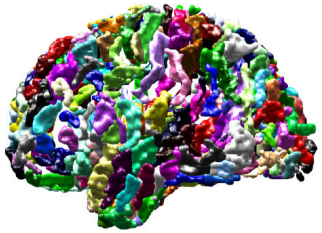


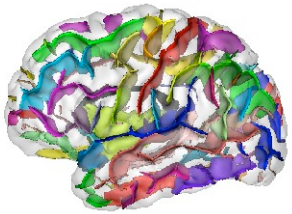
5. Feature matching

Sulcus structures

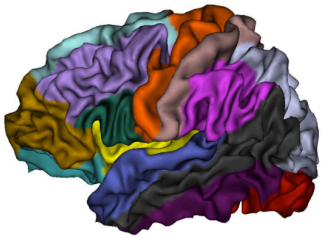


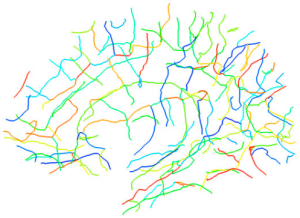
3-D: basins
skeletons



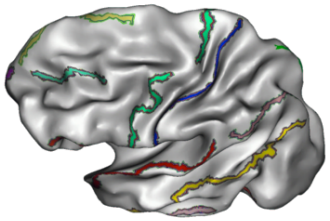


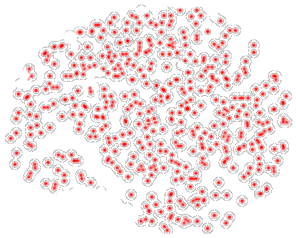
2-D: ribbons
surfaces



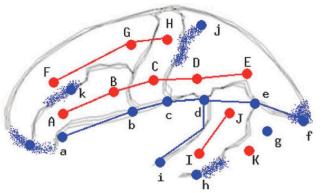


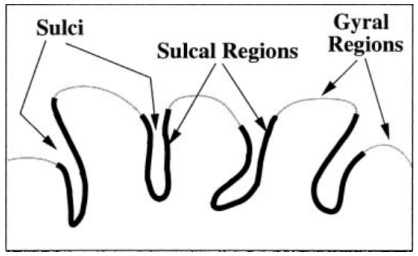
1-D: curves

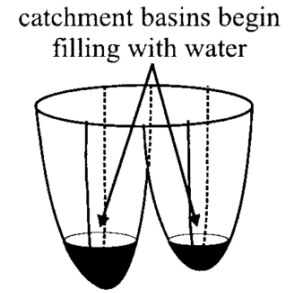


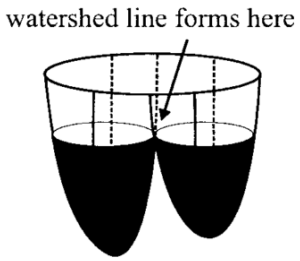


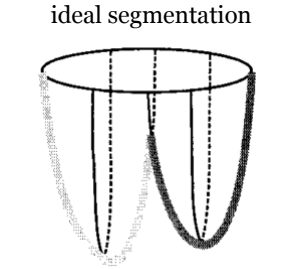
0-D: points
pits



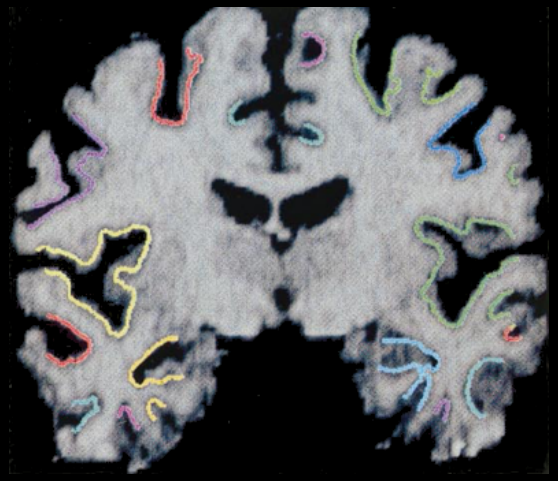


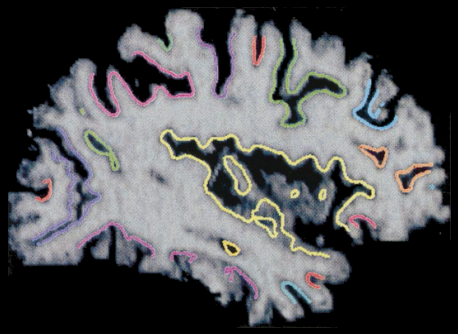




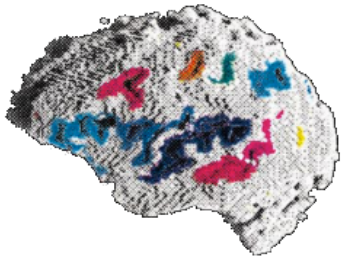


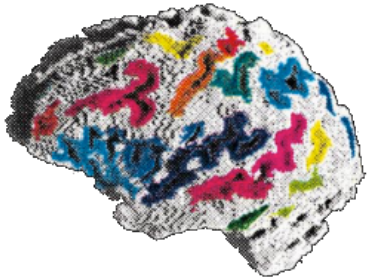
sulcus **basins**

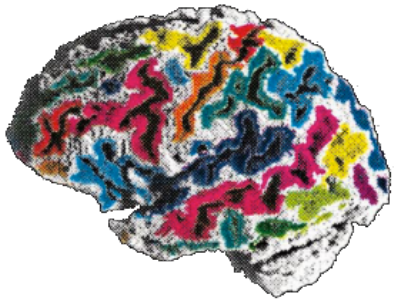


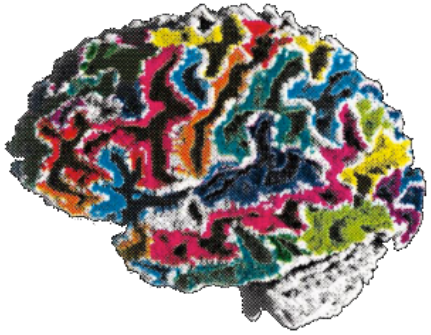


Rettman et al. 2002, Lohmann et al., 2000

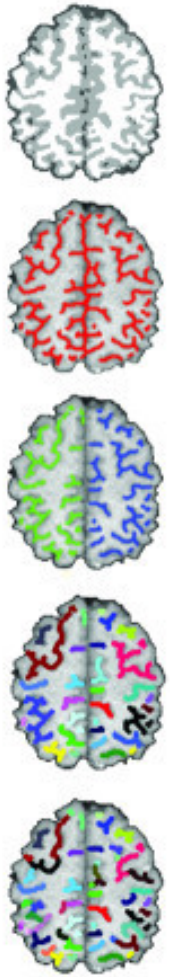


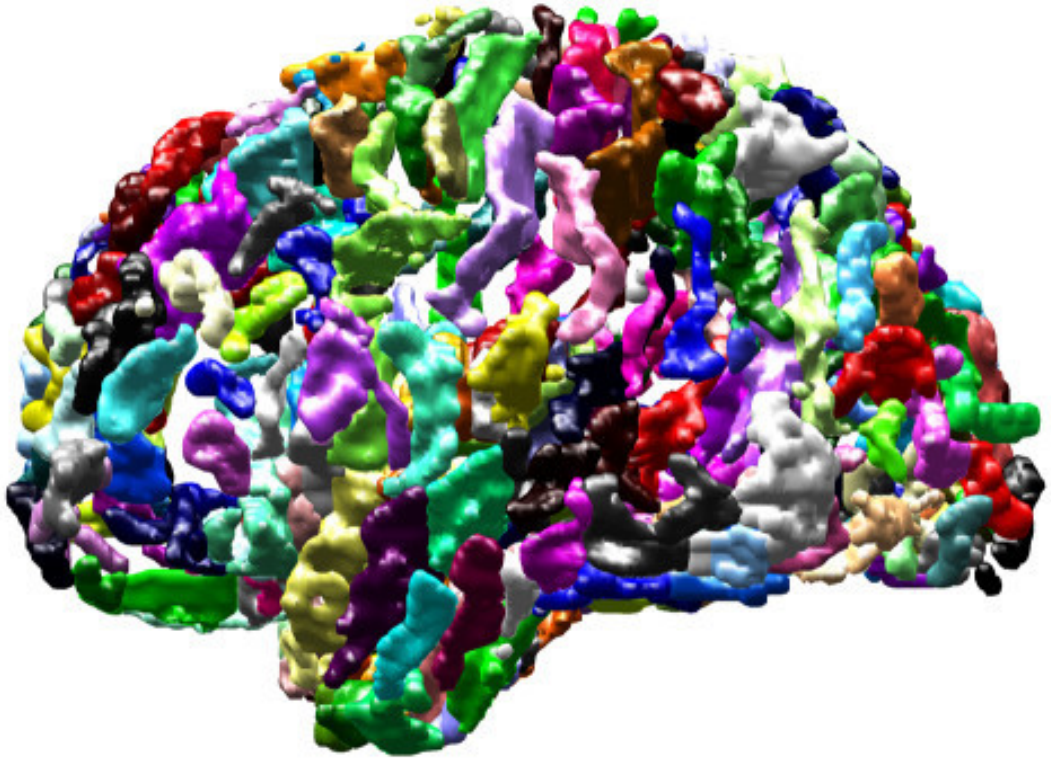




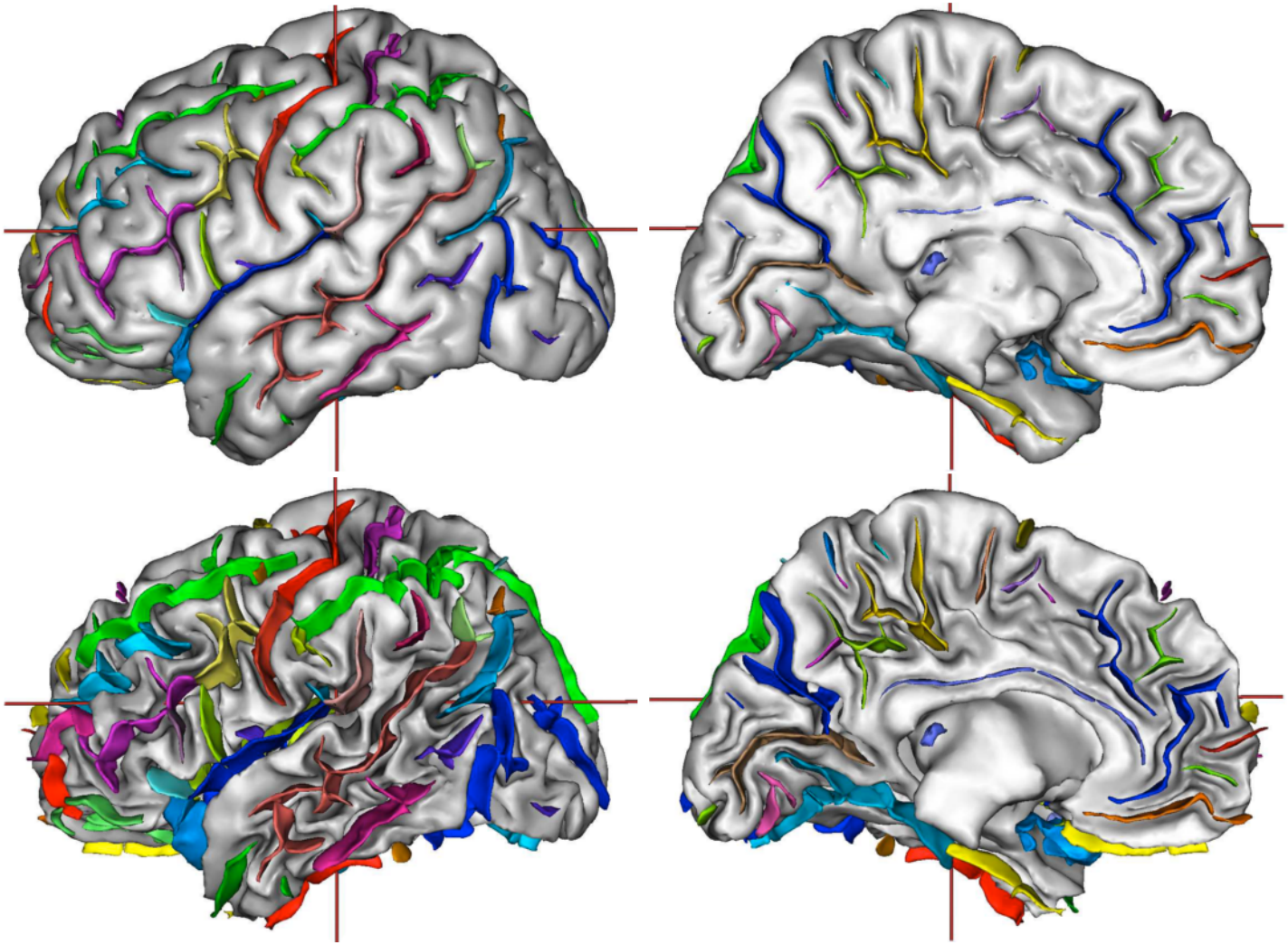


sulcus **skeletons**



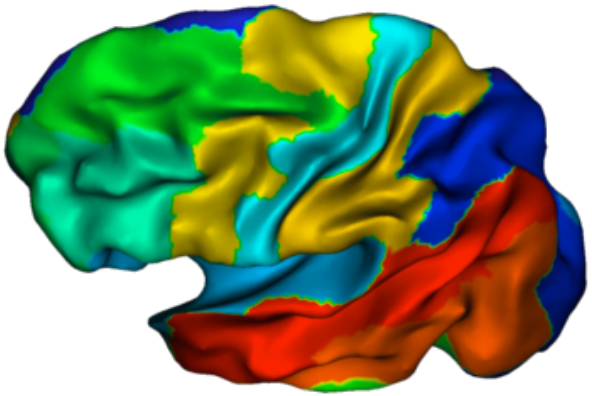


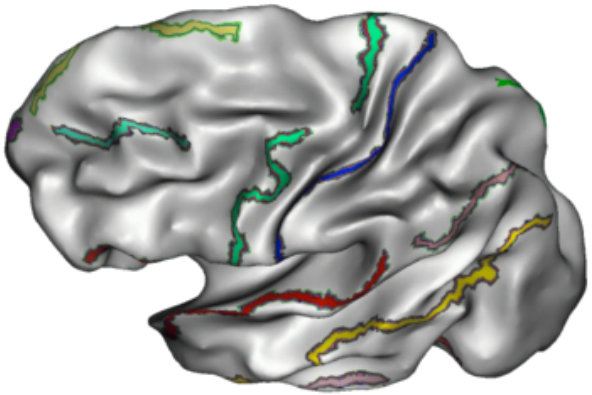
sulcus **ribbons**

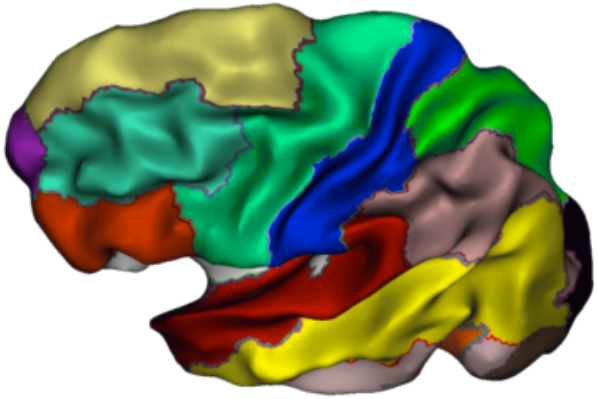


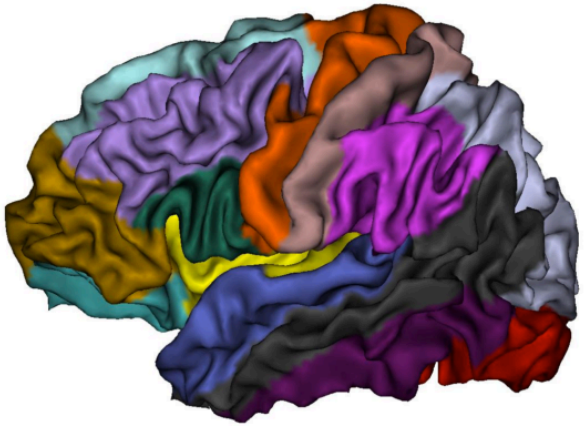
Clouchoux, 2008

sulcus & gyrus **surfaces**



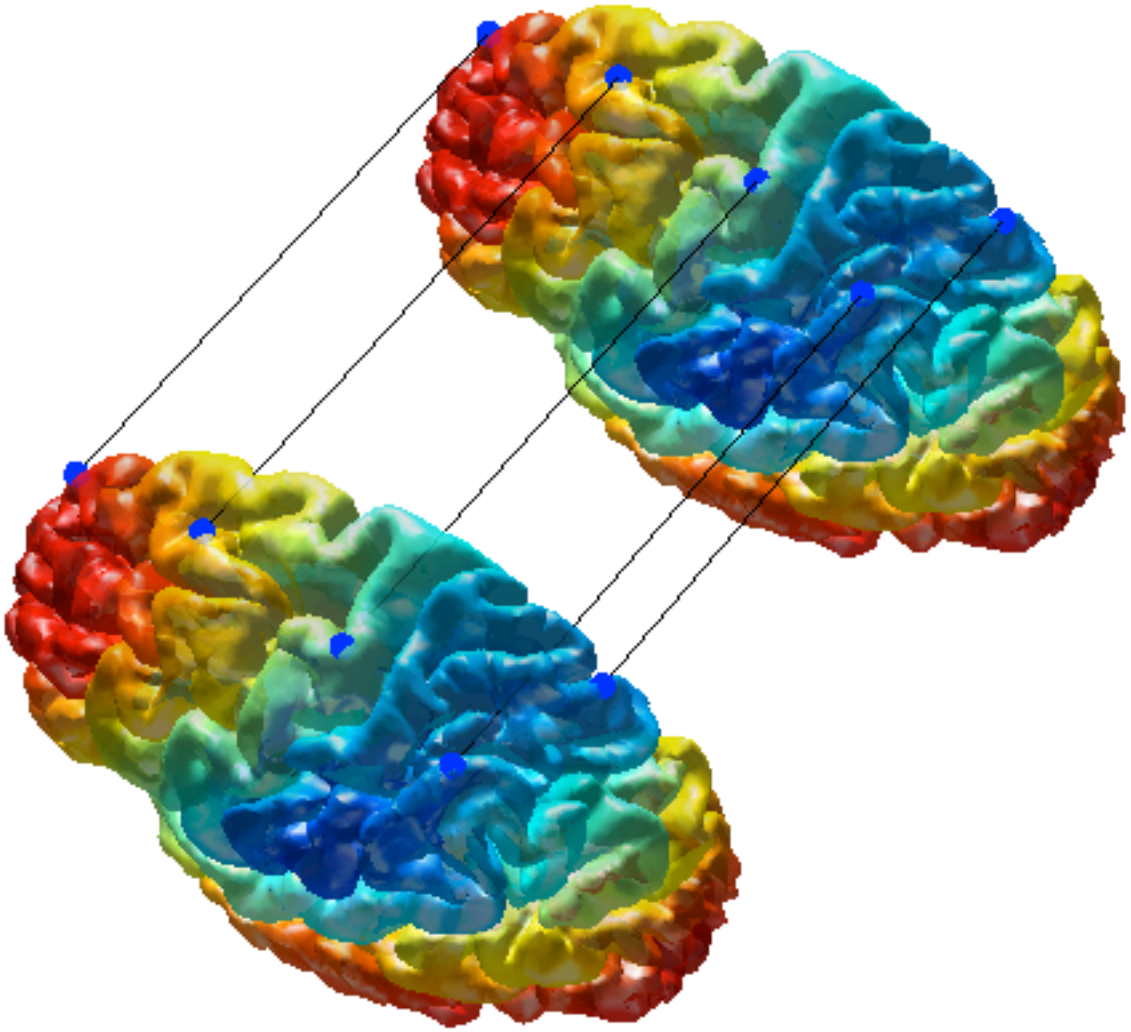




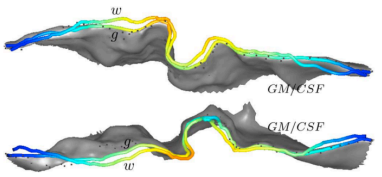


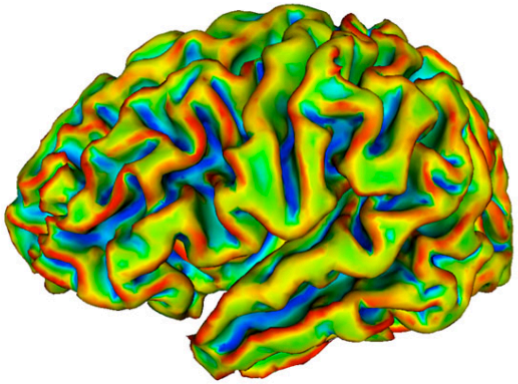
Cachia et al., 2003, Clouchoux et al., 2006

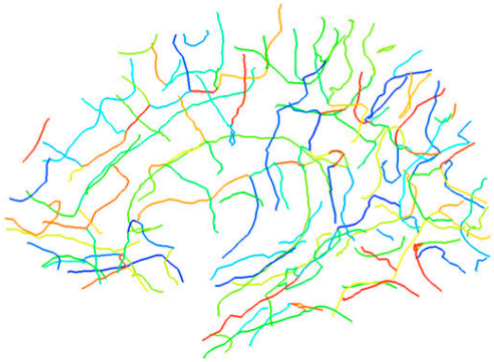
Laplace-Beltrami operator **surfaces**

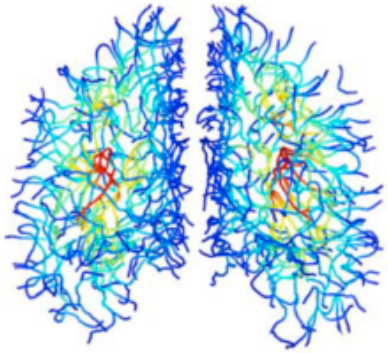


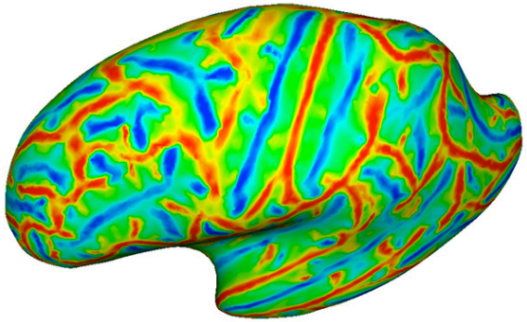
sulcus **curves**

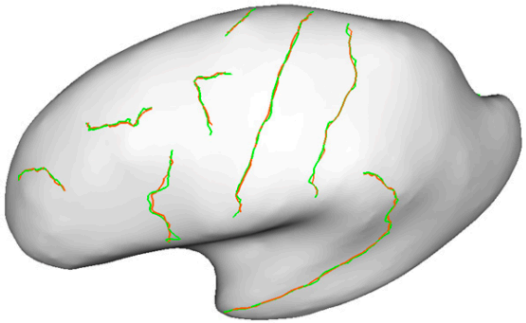


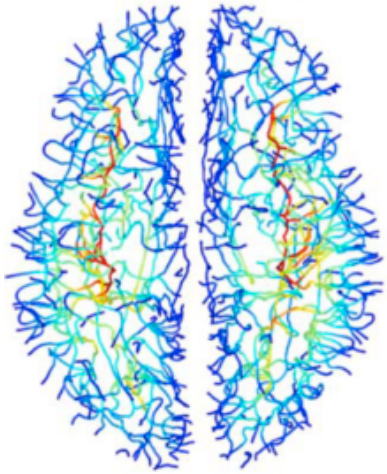






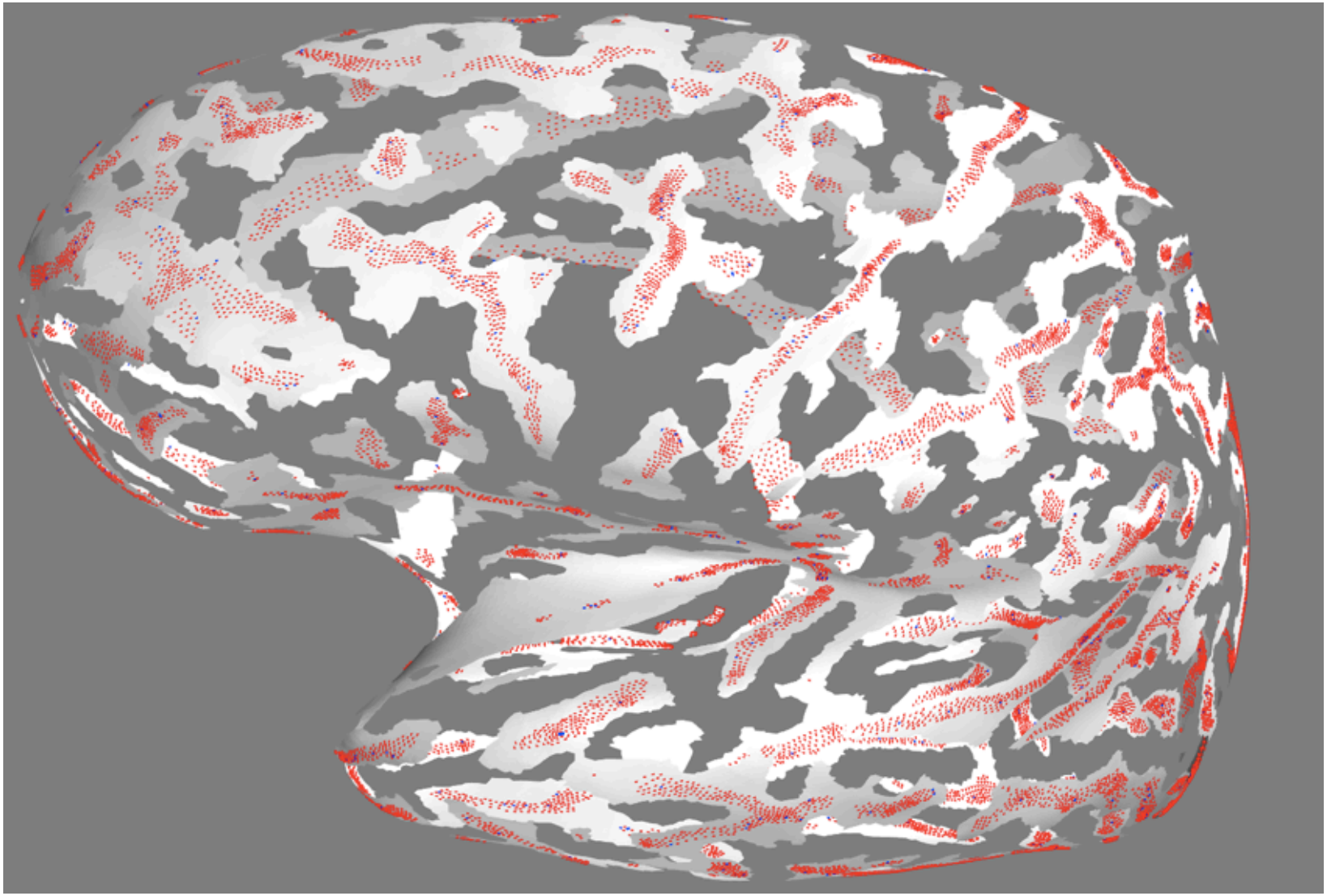




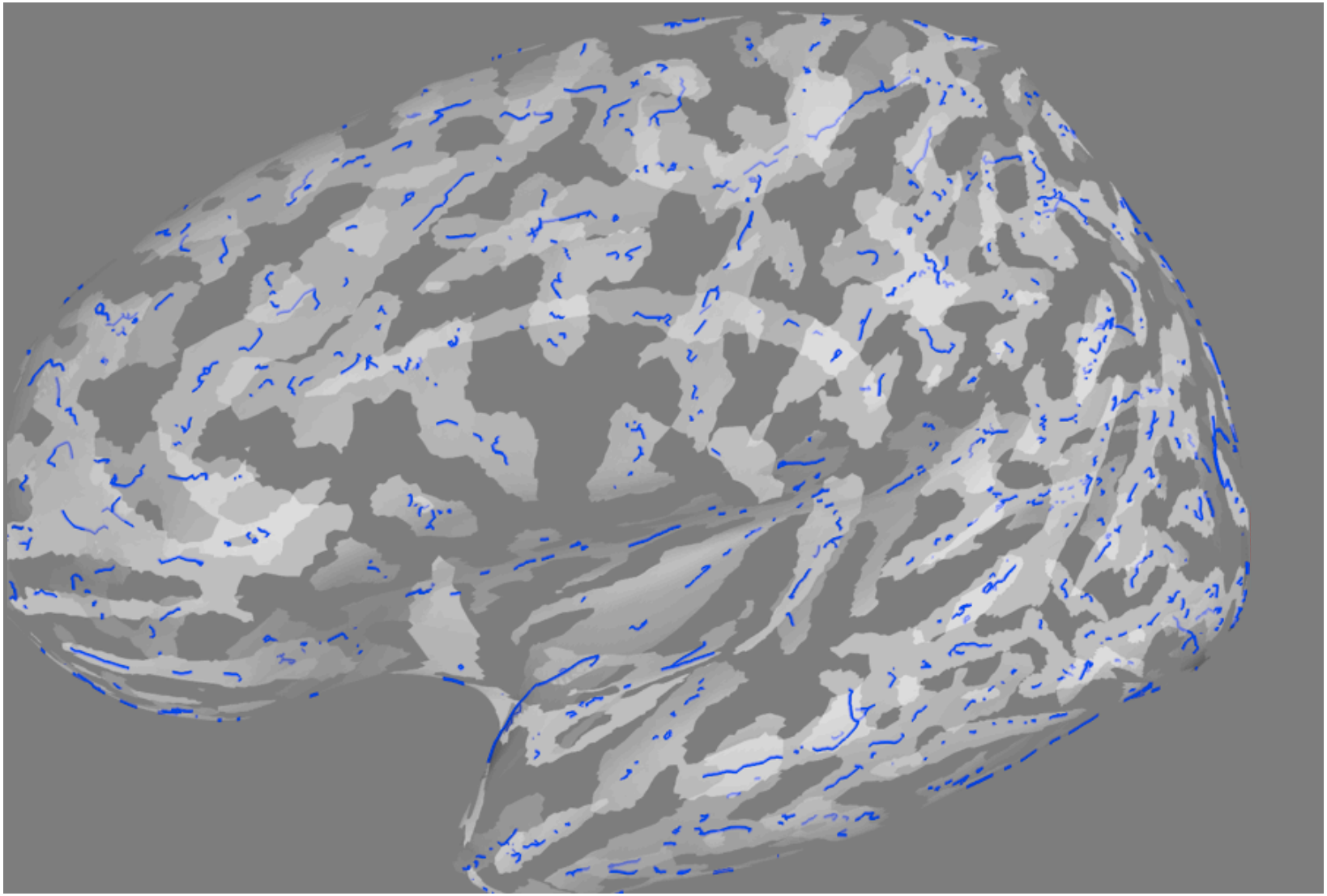


Li et al., 2008, Kao et al., 2007

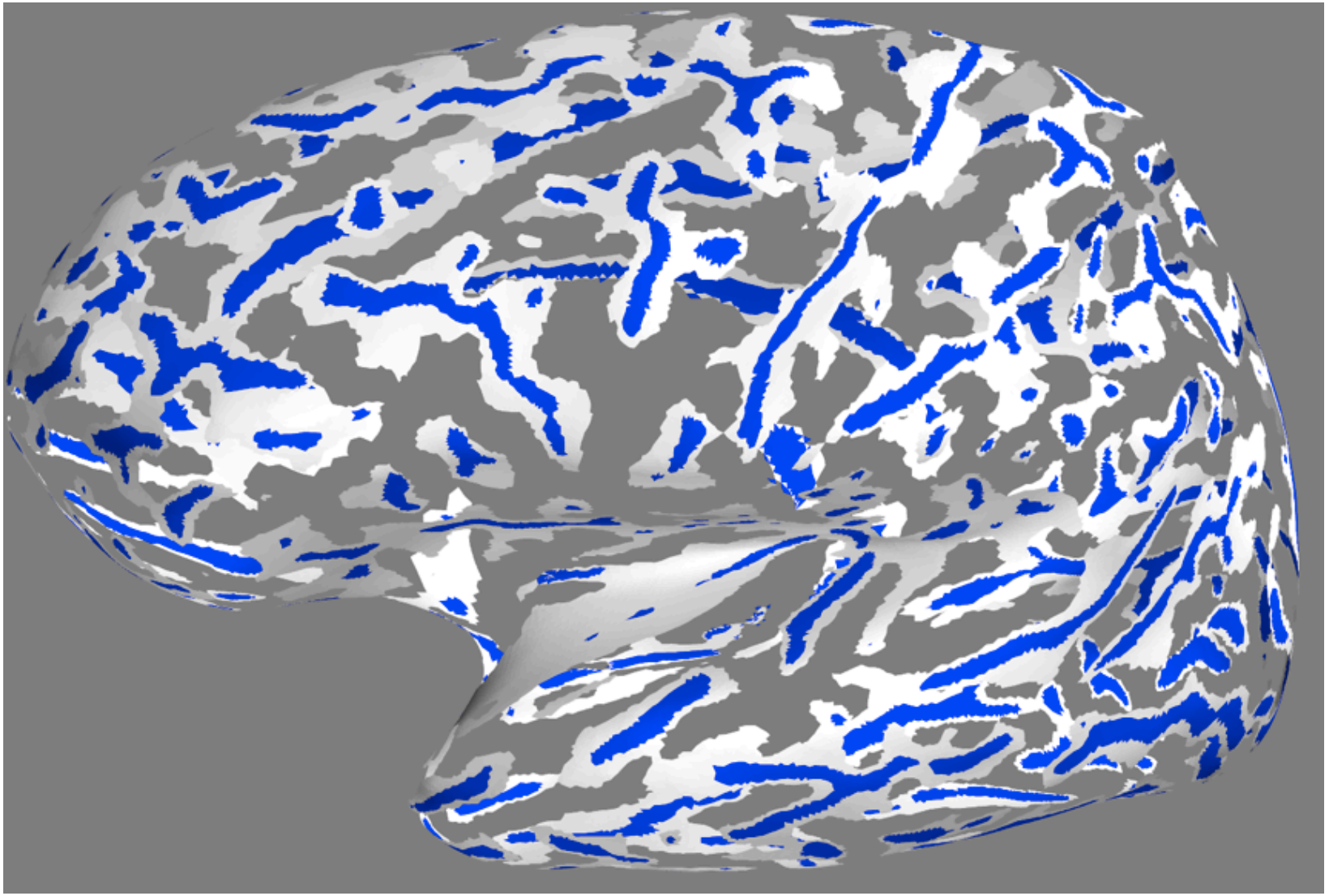
sulcus **curves**



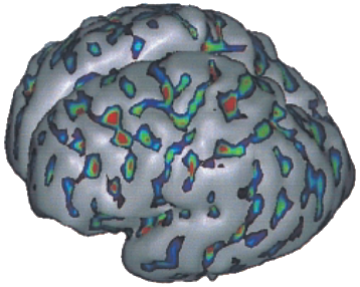
sulcus **curves**

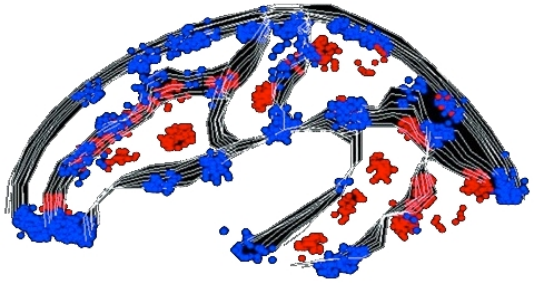


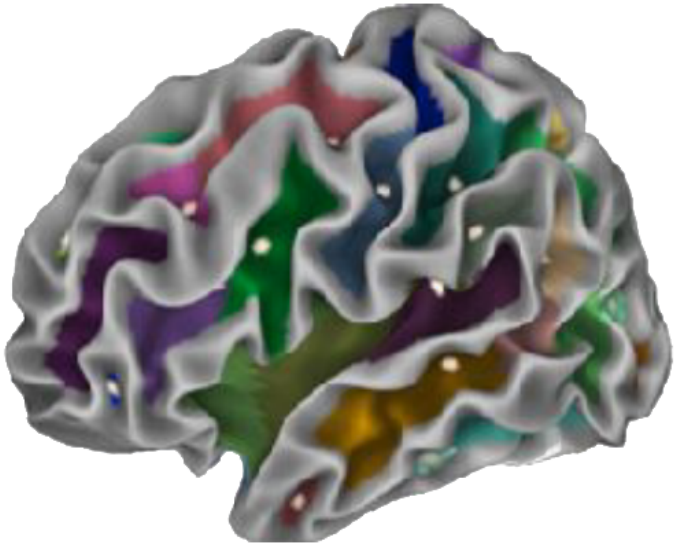
sulcus **curves**

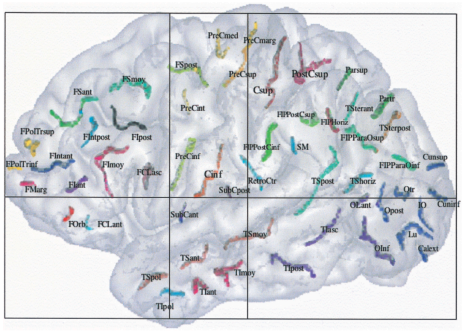


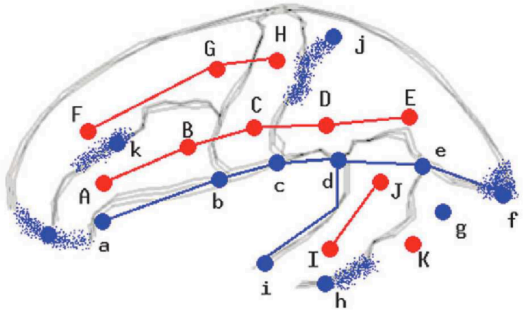
sulcus **pits**







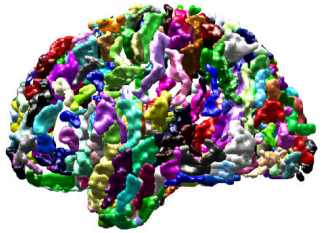


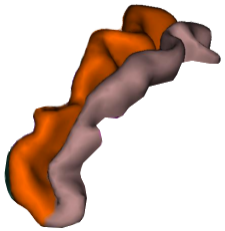


Regis et al., 2005, Im et al., 2010, Lohmann et al., 2007

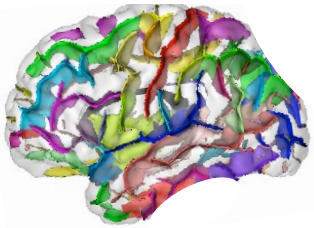
Combine stuctures in a nested hierarchy

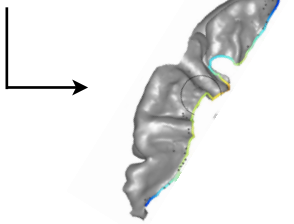
3-D



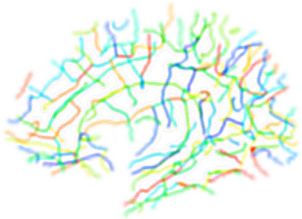


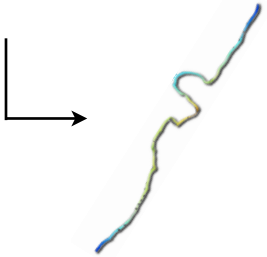
2-D



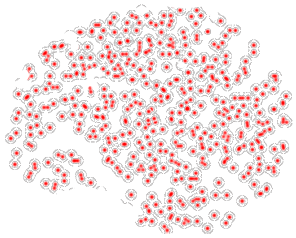


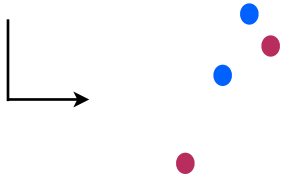
1-D





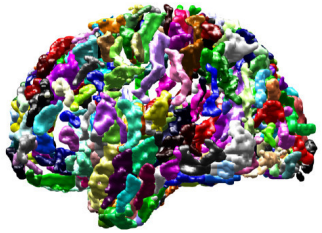
0-D

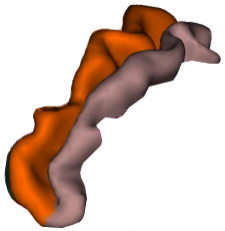




Characterize their shapes: **features**

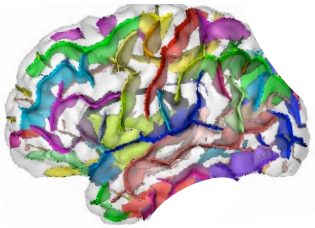
3-D





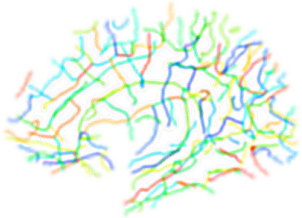
volume
surface area
lengths (thickness)
...

2-D



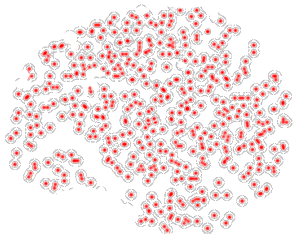
area
curvature
convexity
spectral components
...

1-D



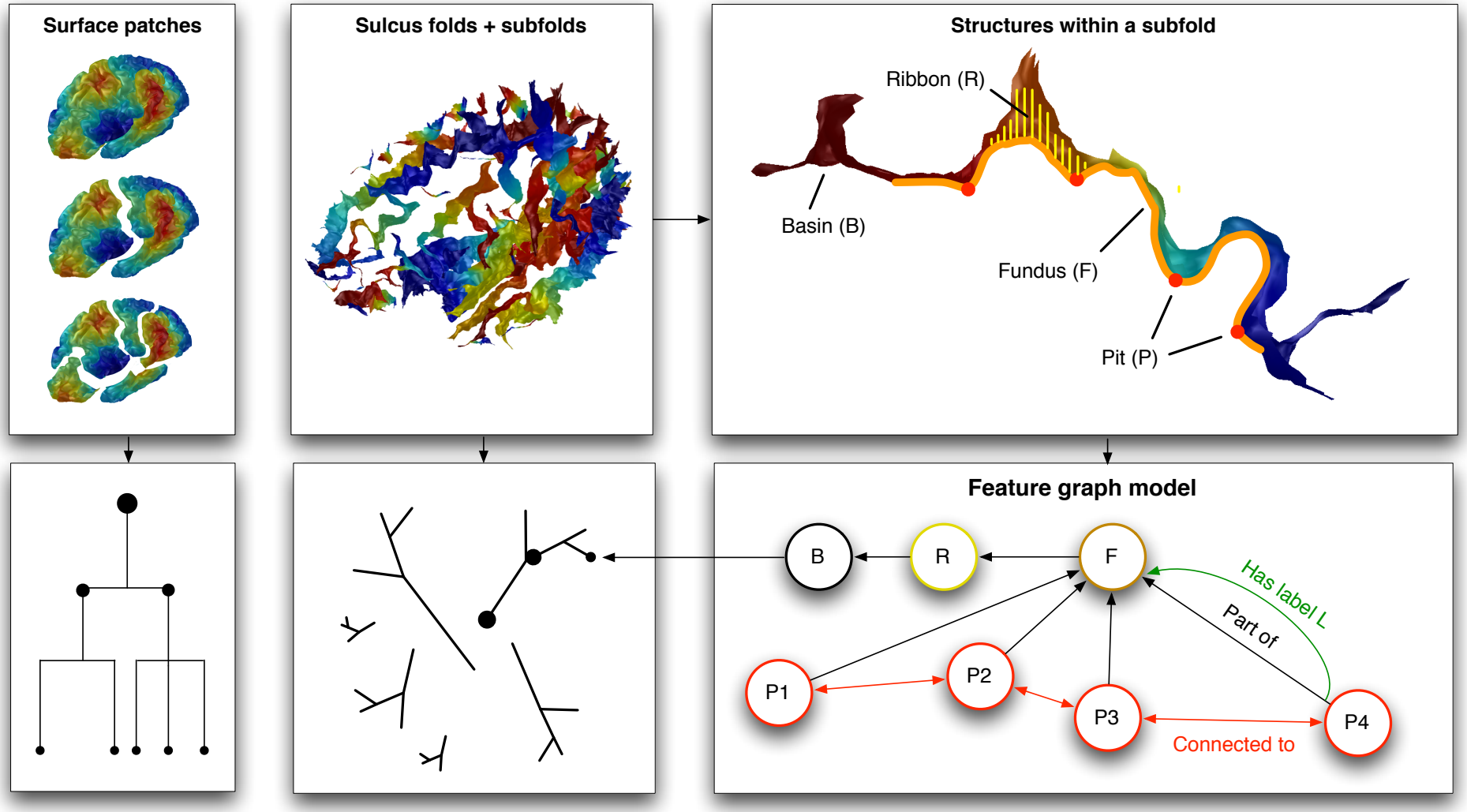
length
curvature
convexity
...

0-D



3-D convex hull volume
1-D sequence along a curve
...

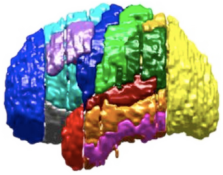
Represent nested features within a graph-based data model

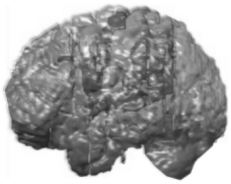


Top: structures: surface patches fragmented by application of the Laplace-Beltrami operator, sulcus folds and subfolds, and structures within a subfold.
Bottom: schematic diagrams representing the hierarchical relationships among nested structures.
Bottom right: features as properties of edges (relationships: Part of, Connected to, Has label) and nodes (geometric, shape, spectral, and connectivity measures).

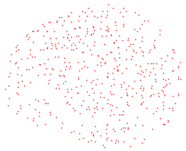
Mindboggle 2: feature-based labeling

atlas



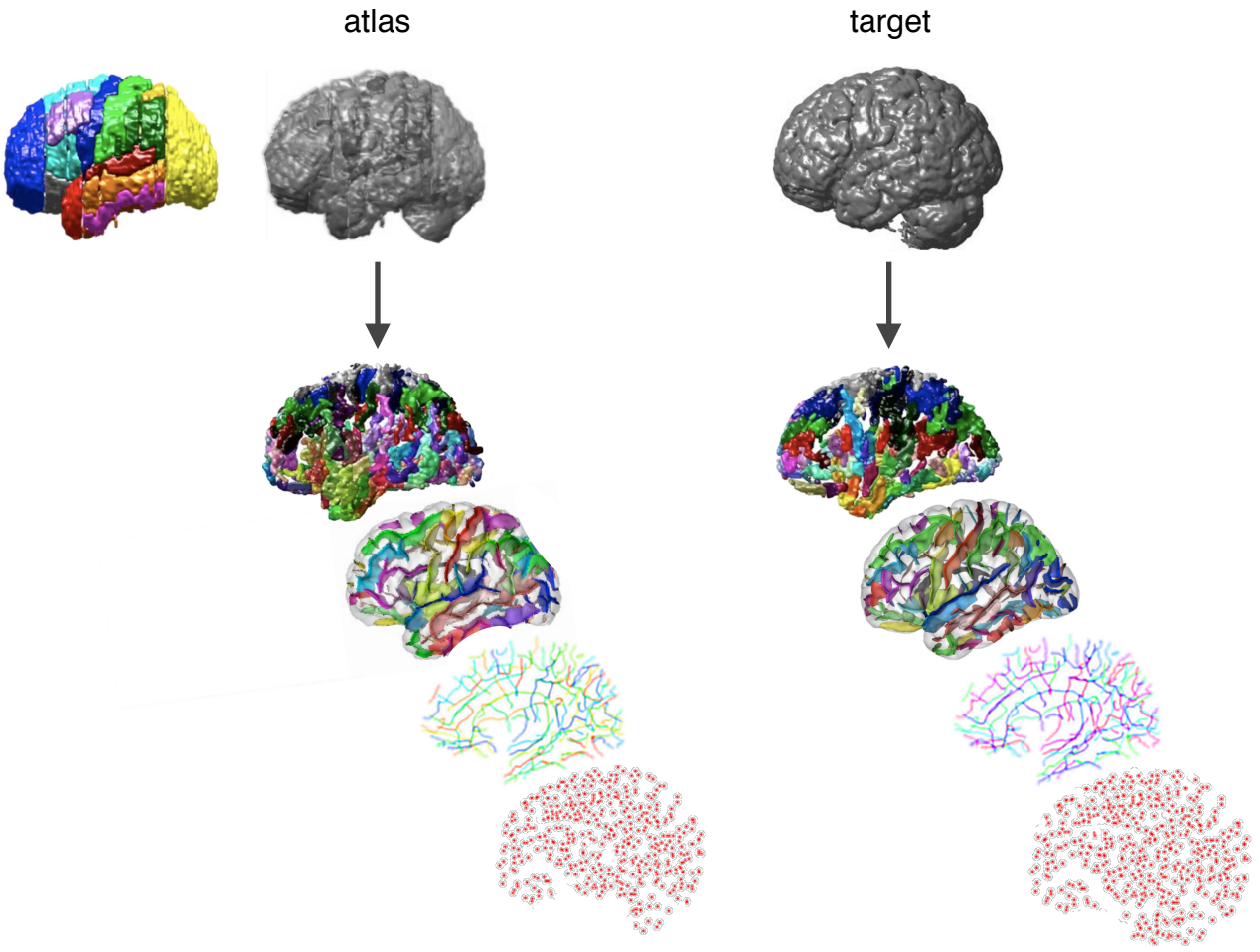


target



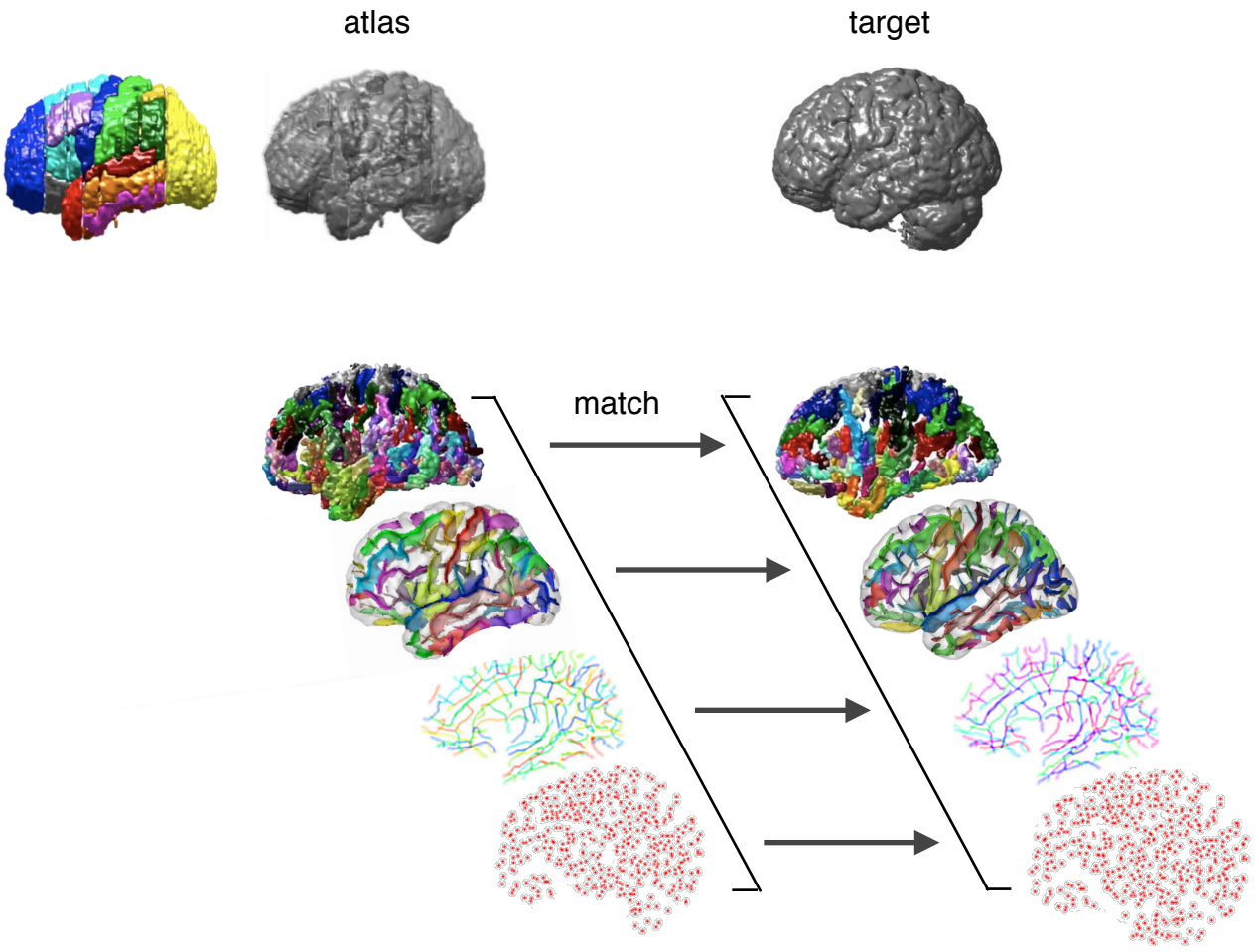
Mindboggle 2: feature-based labeling

Step 1: extract structures, compute their features



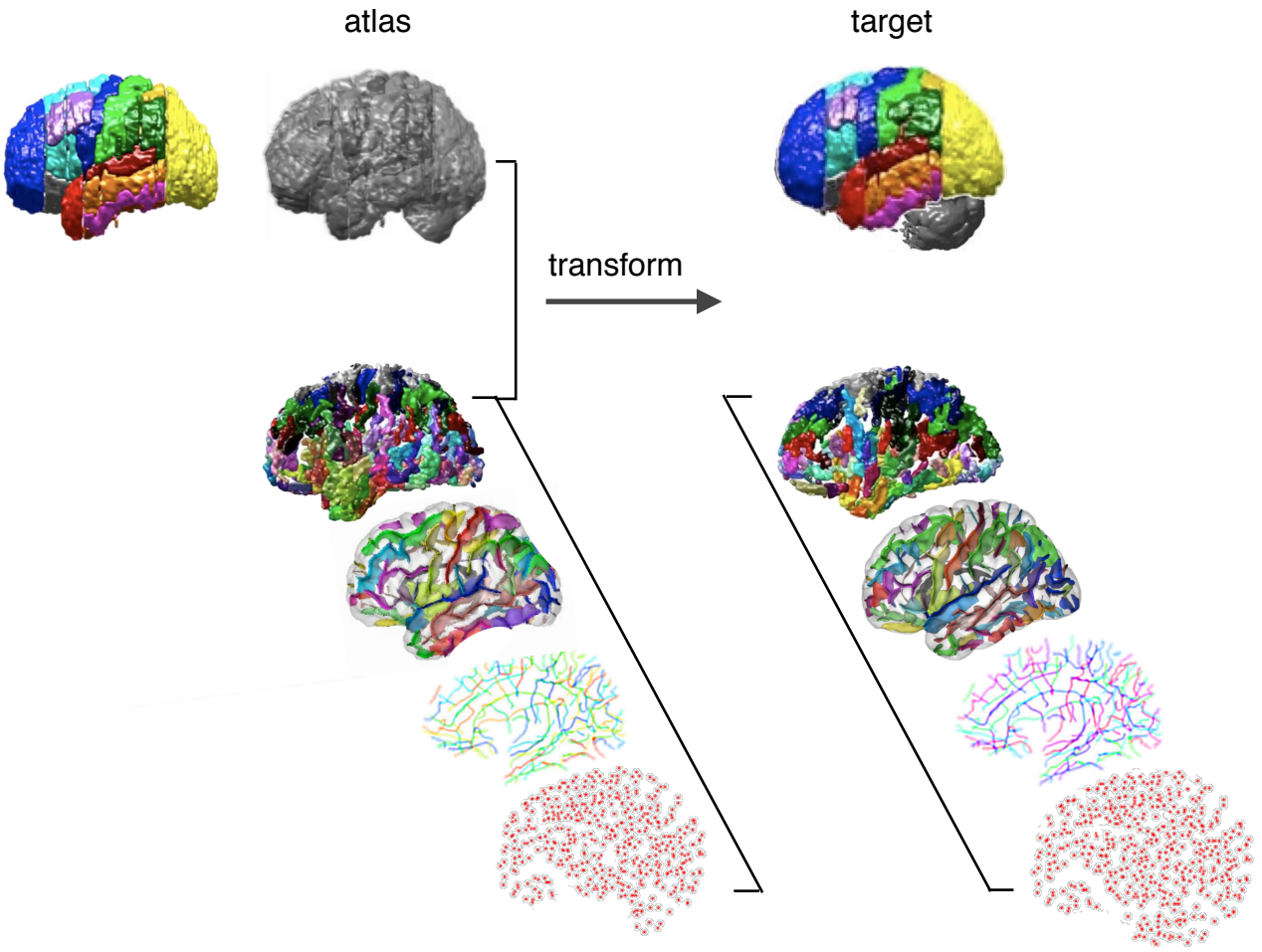
Mindboggle 2: feature-based labeling

Step 2: match atlas and target features



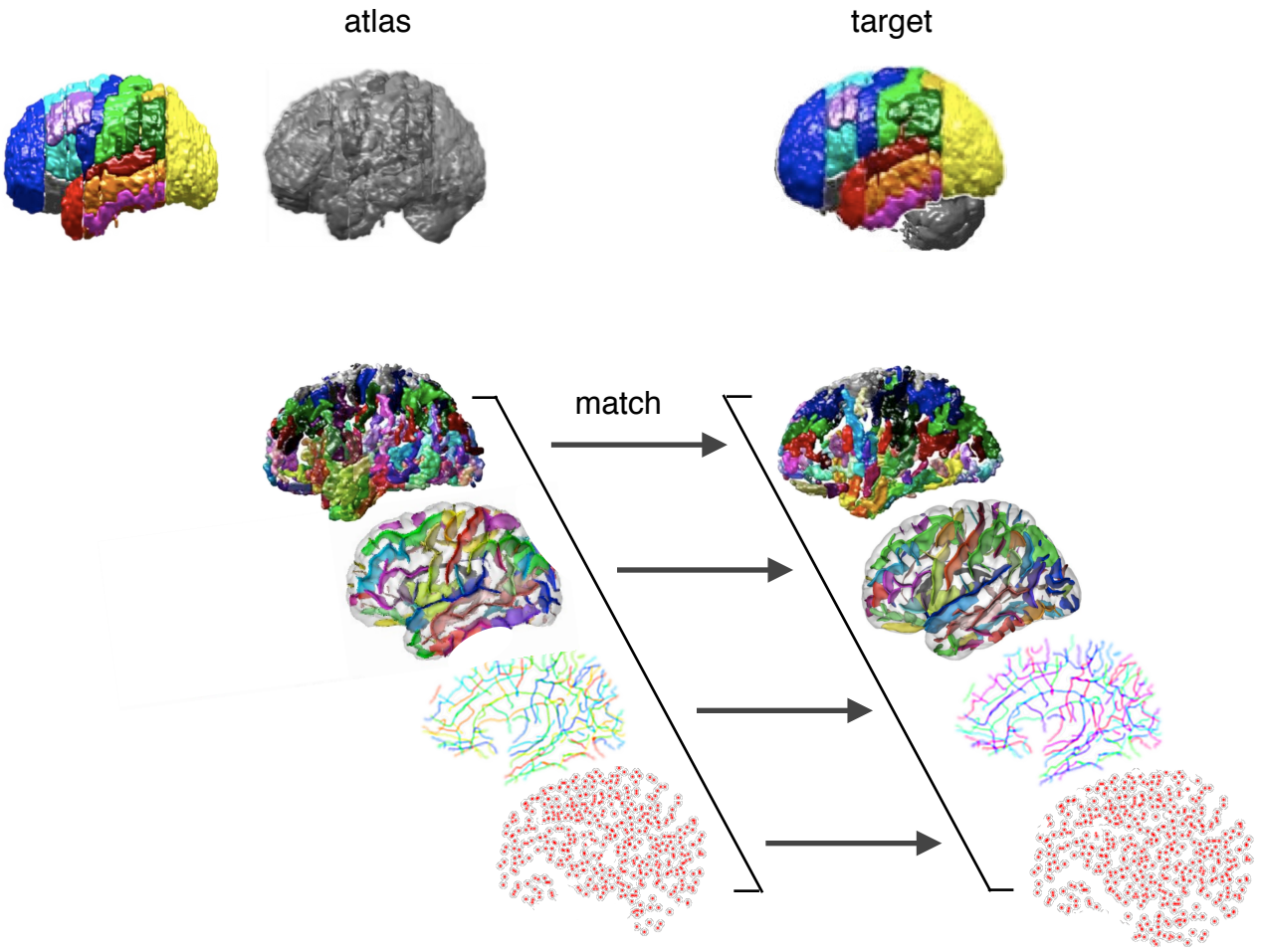
Mindboggle 2: feature-based labeling

Step 3: register atlas and target structures



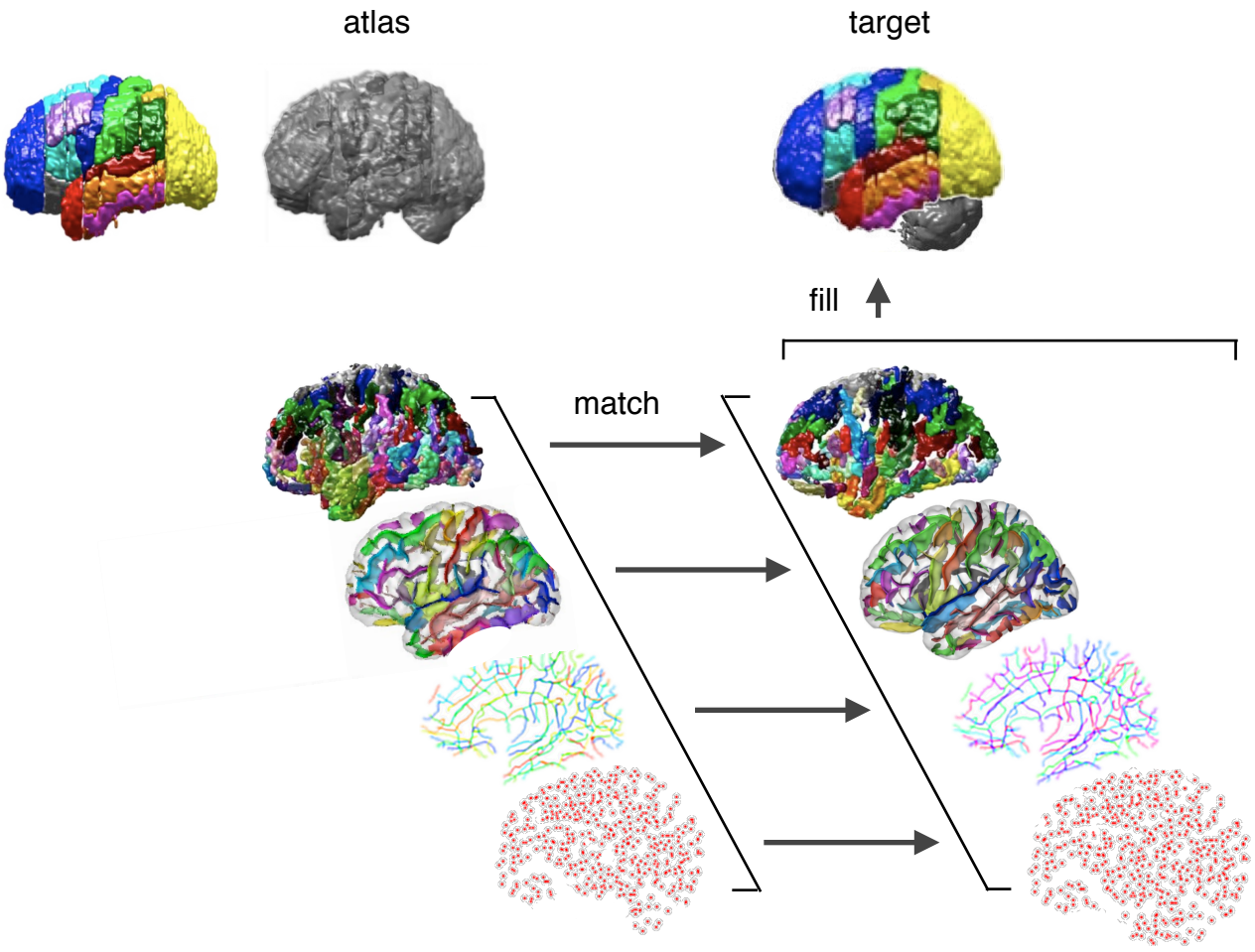
Mindboggle 2: feature-based labeling

Step 2: or match features...

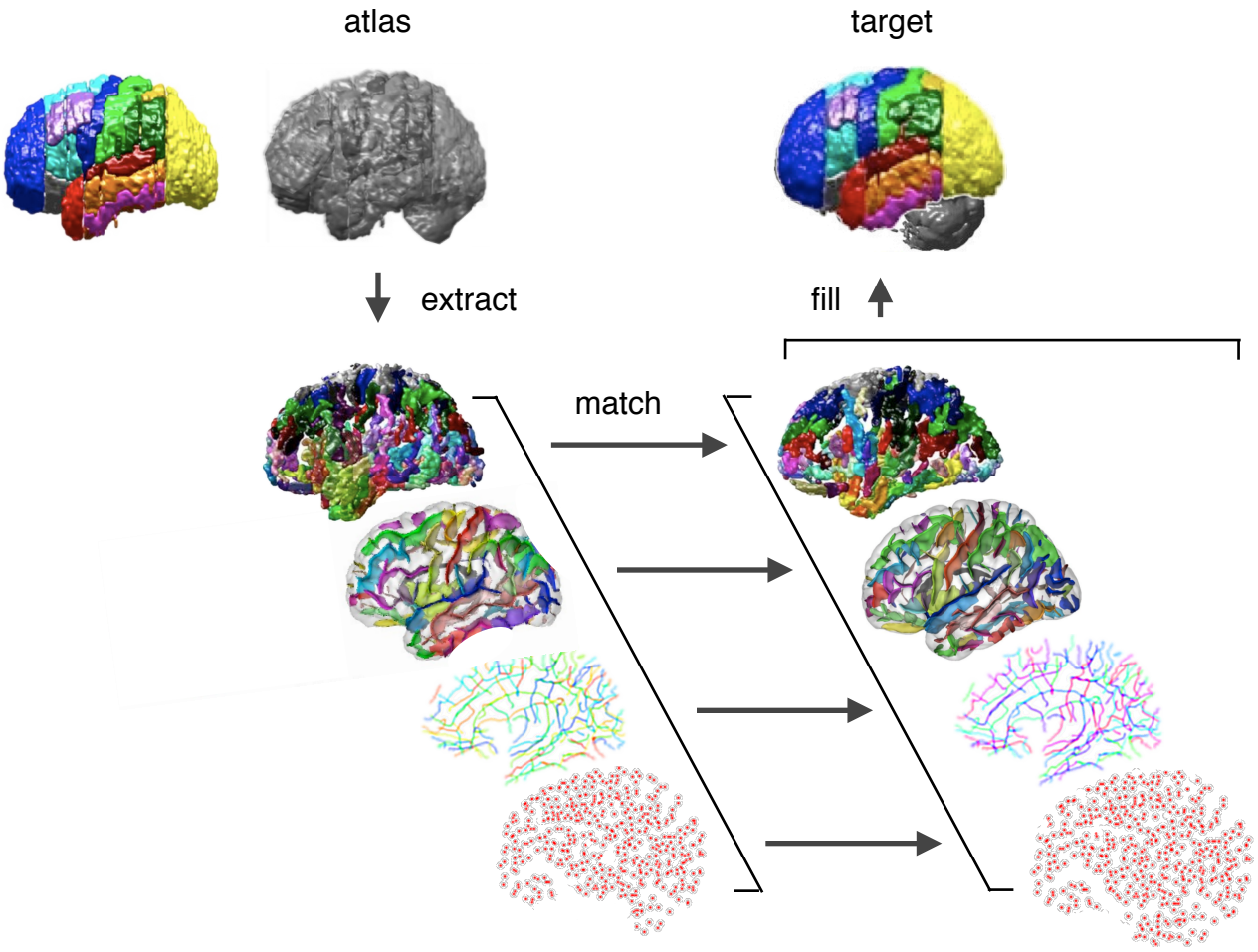


Mindboggle 2: feature-based labeling

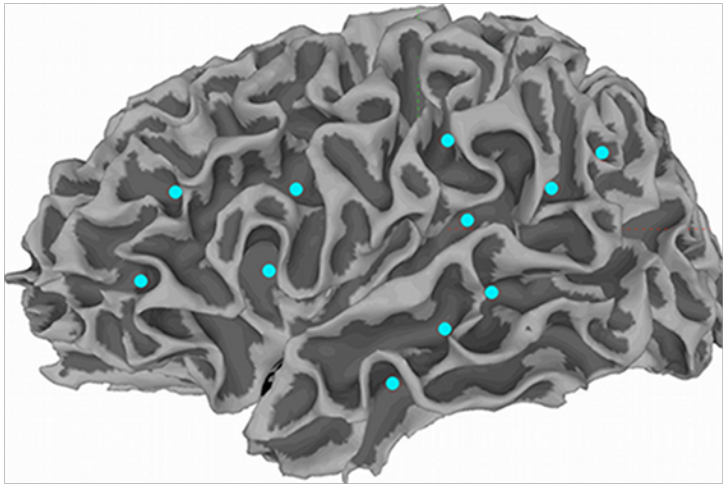
Step 3: then propagate labels within inferred label boundaries



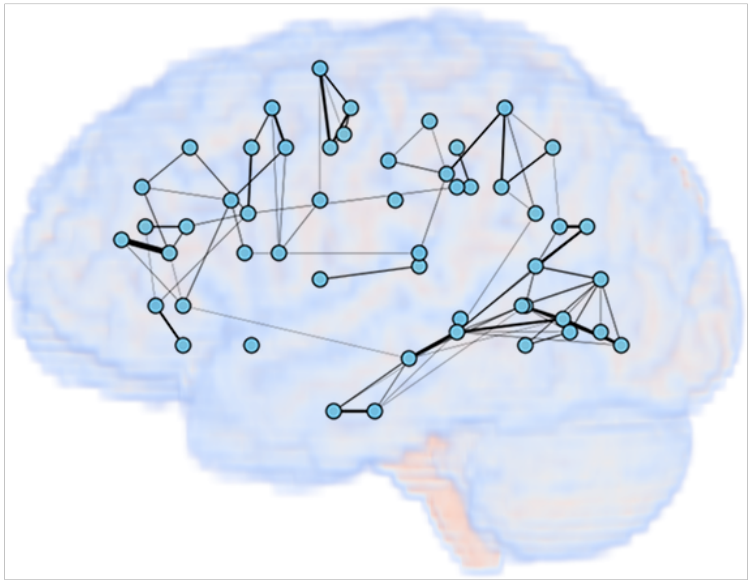
Mindboggle 2: feature extraction
feature matching
feature-based labeling



Combine structures across modalities

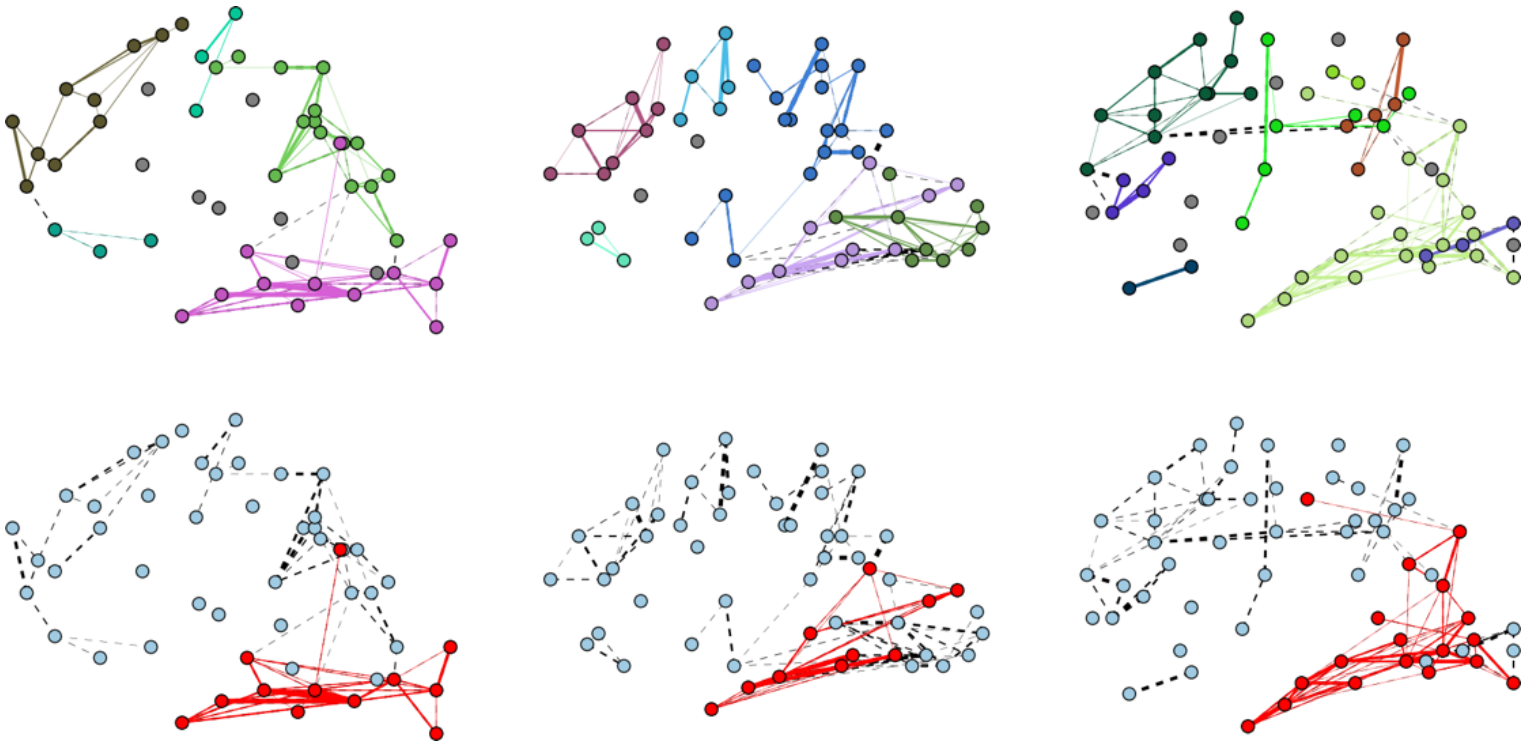


A gray/white matter surface (left lateral view) with visible sulcal pits highlighted (cyan circles). These features go by different names (sulcal roots, buried or annectant gyrii, plis de passage) and may be well conserved structures formed early in development.



DTI connectivity graph (same subject). Vertices represent all extracted sulcal pits and each edge width indicates a connection probability greater than 0.01 between two vertices (and does not follow a tractography path).

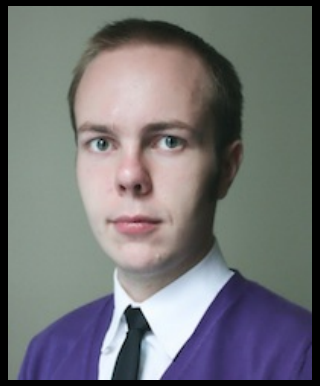
Match “brain graphs”



Early attempt at subgraph extraction (upper row) and matching (lower row).
These graphs were constructed from (left to right) a remitter, non-remitter, and control subject.
The subgraphs in red in the lower row have the highest small-worldness ratio.

Forrest Bao (Texas Tech)
Anatomical feature extraction

Noah Lee
Alt. features (spectral, machine learning)
Graph-based feature database



Yrjo Hame
Feature matching

Denis Peruzzo
Feature graph matching
DTI tractography

Mireia Montanola (intern)
Surface parametrization

Brian Avants (UPenn)
Diffeomorphic registration