Brain labeling, feature identification and shape analysis

CSE 600
August 31, 2012

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http://mindboggle.info
research asst. professor
psychiatry and behavioral science
stony brook university

Mindboggle team

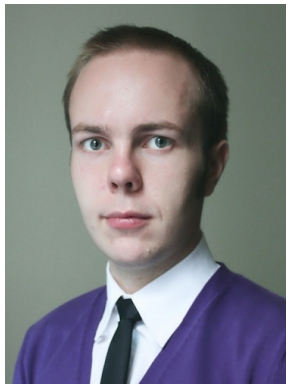
Depth and curvature

Joachim Giard
Univ. Catholique de Louvain, Belgium

Nested features

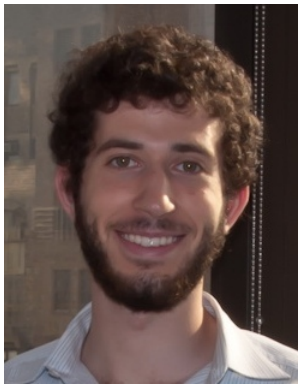
Forrest Bao
Texas Tech

Probabilistic features



Yrjö Häme
Columbia PhD student

Label propagation



Eliezer Stavsky
Columbia PhD student

Anatomical labeling

Jason Tourville
Boston U.

Greg Millington
Neuromorphometrics, Inc.

dMRI features

Eleftherios Garyfallidis
Cambridge University

Machine learning

Satrajit Ghosh
MIT

Why label brain features?

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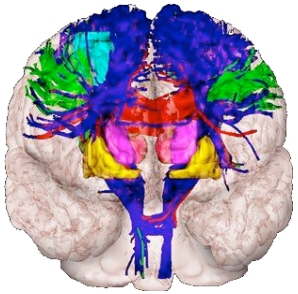
Labels visually augment anatomy

- teach anatomy
- guide surgery



http://www.cbd.ucla.edu/bios/iacoboni.html, http://brainvisa.info/, http://dx.doi.org/10.1126/science.1145876
http://groups.csail.mit.edu/vision/medical-vision/past-projects.html, http://www.spl.harvard.edu/publications/item/view/1265

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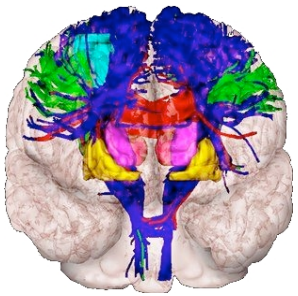
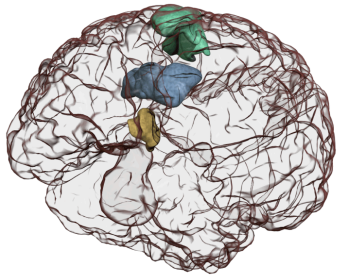


Labels break up data

- process data by region
- quantify and report data by region



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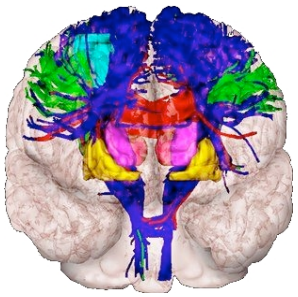

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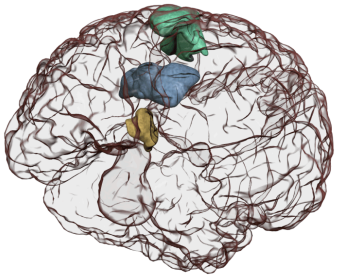
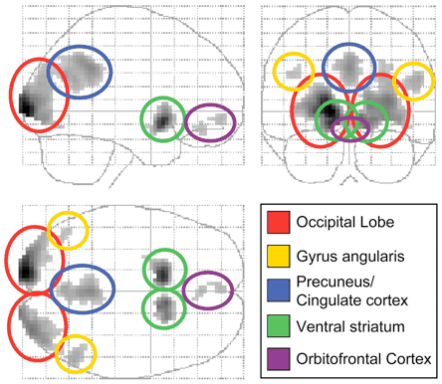


Labels identify corresponding objects

- communicate using the same terms
- compare data across subjects and studies



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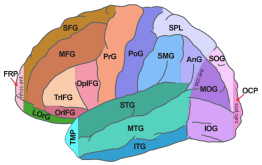
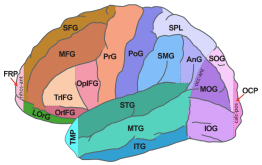
Current work on Mindboggle



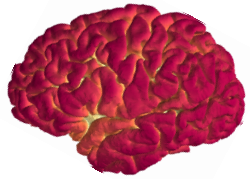
101 manually labeled brain atlases
and shape database

Current Mindboggle

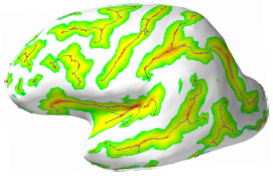


101 manually labeled brain atlases and shape database

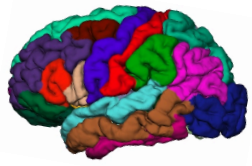
Mindboggle software:



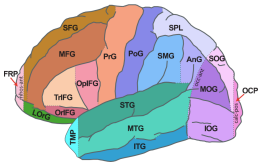
- measures shapes



- identifies features

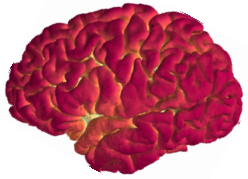


- labels regions

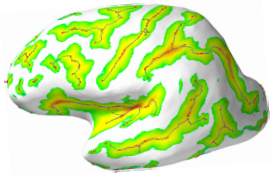


manual

Mindboggle



morphometry



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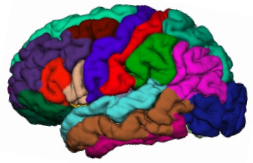
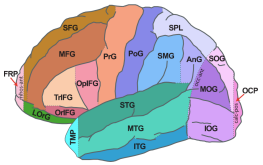


labels



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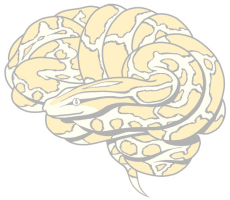
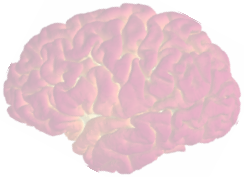


Mindboggle



morphometry

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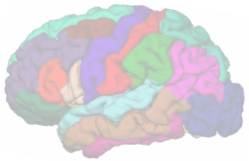

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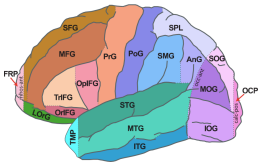

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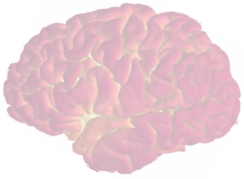

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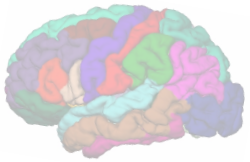

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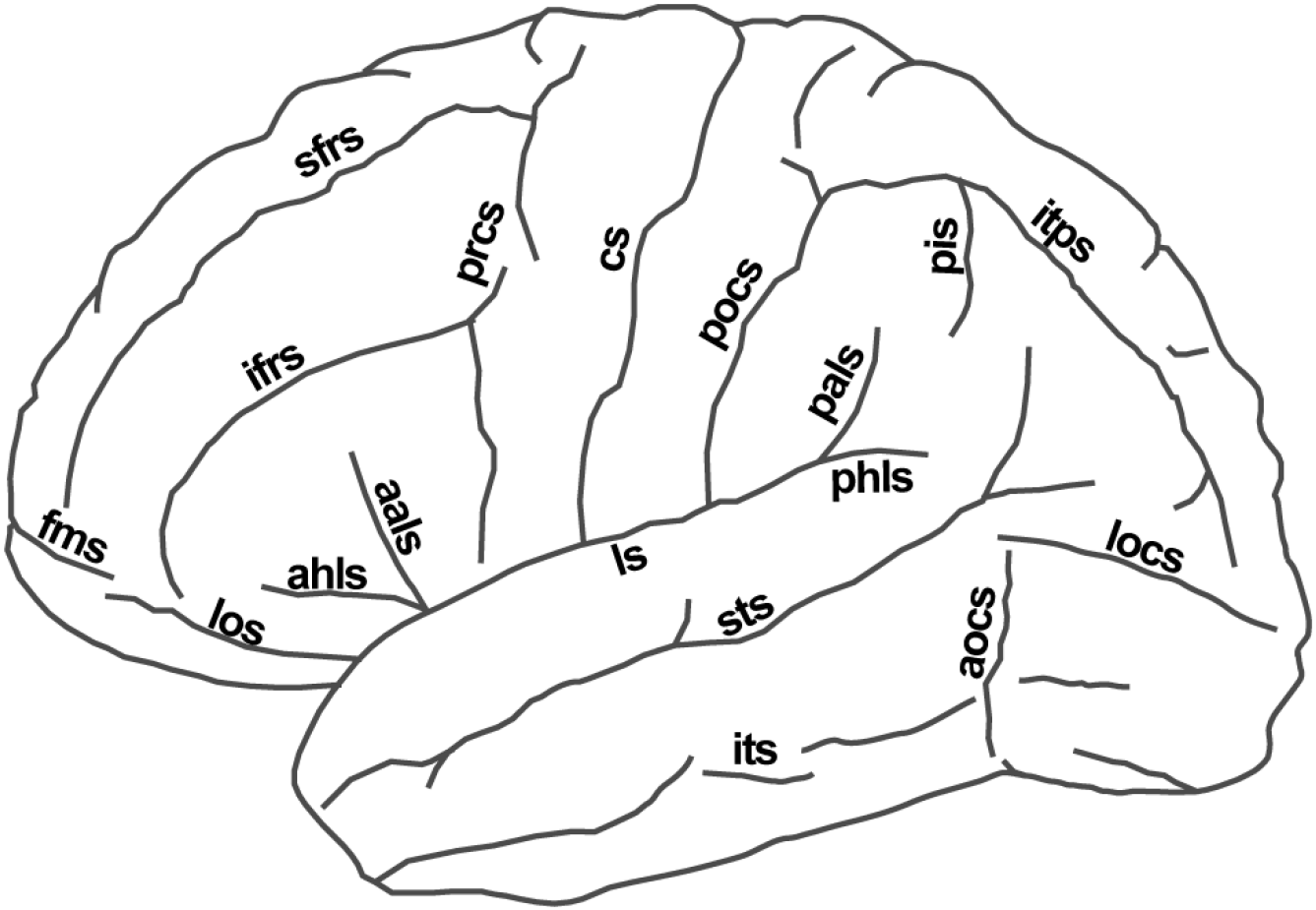
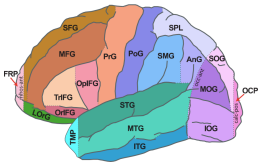


Creases (“sulcus folds”)



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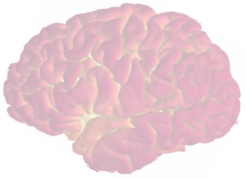
Mindboggle



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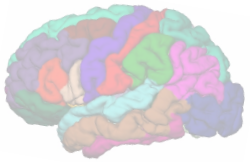

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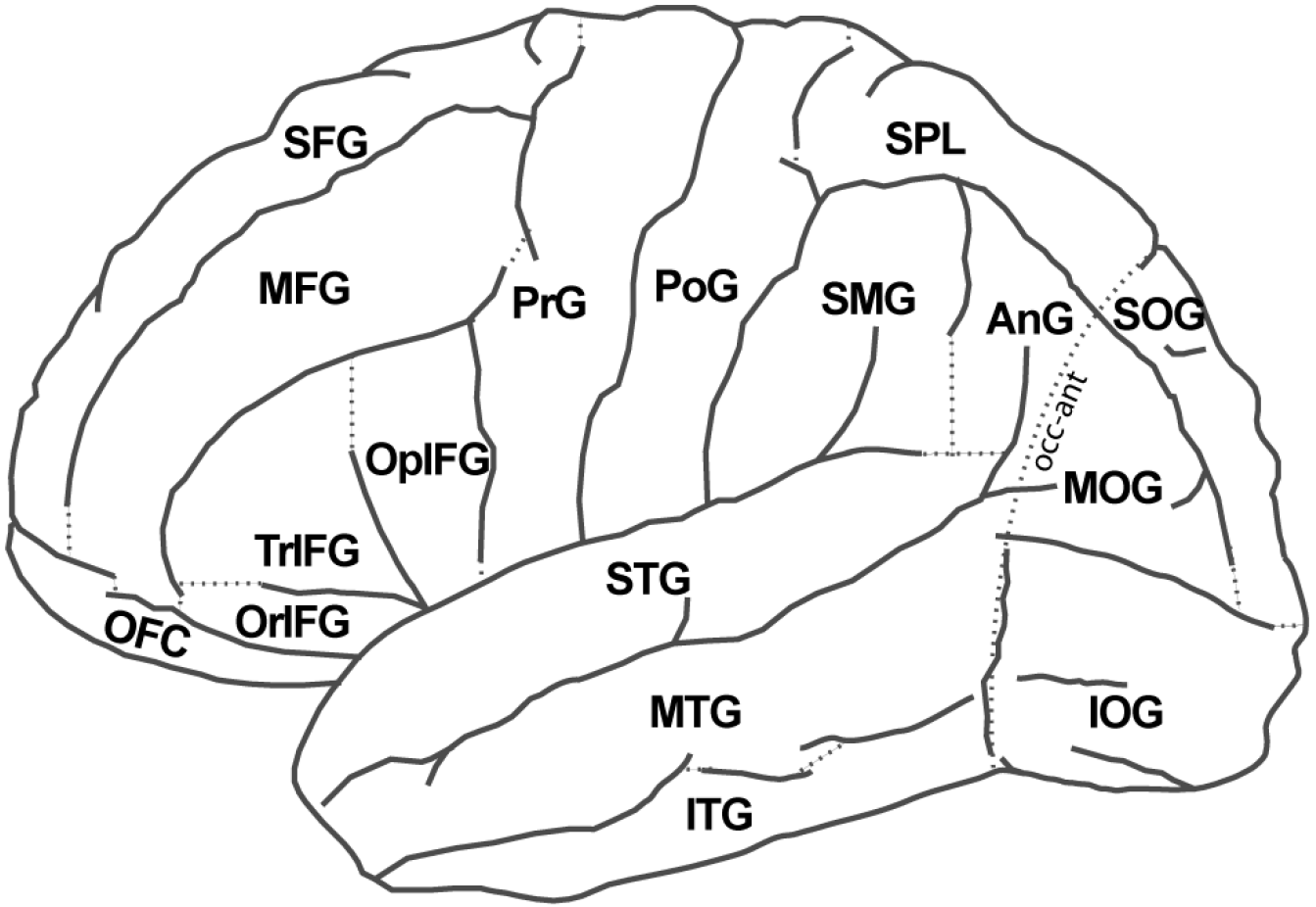
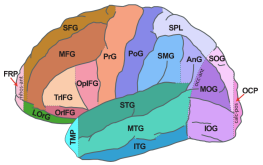


Exterior surface (“gyrus regions”)



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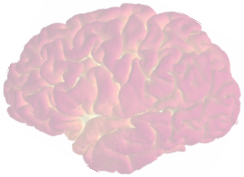

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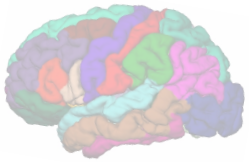

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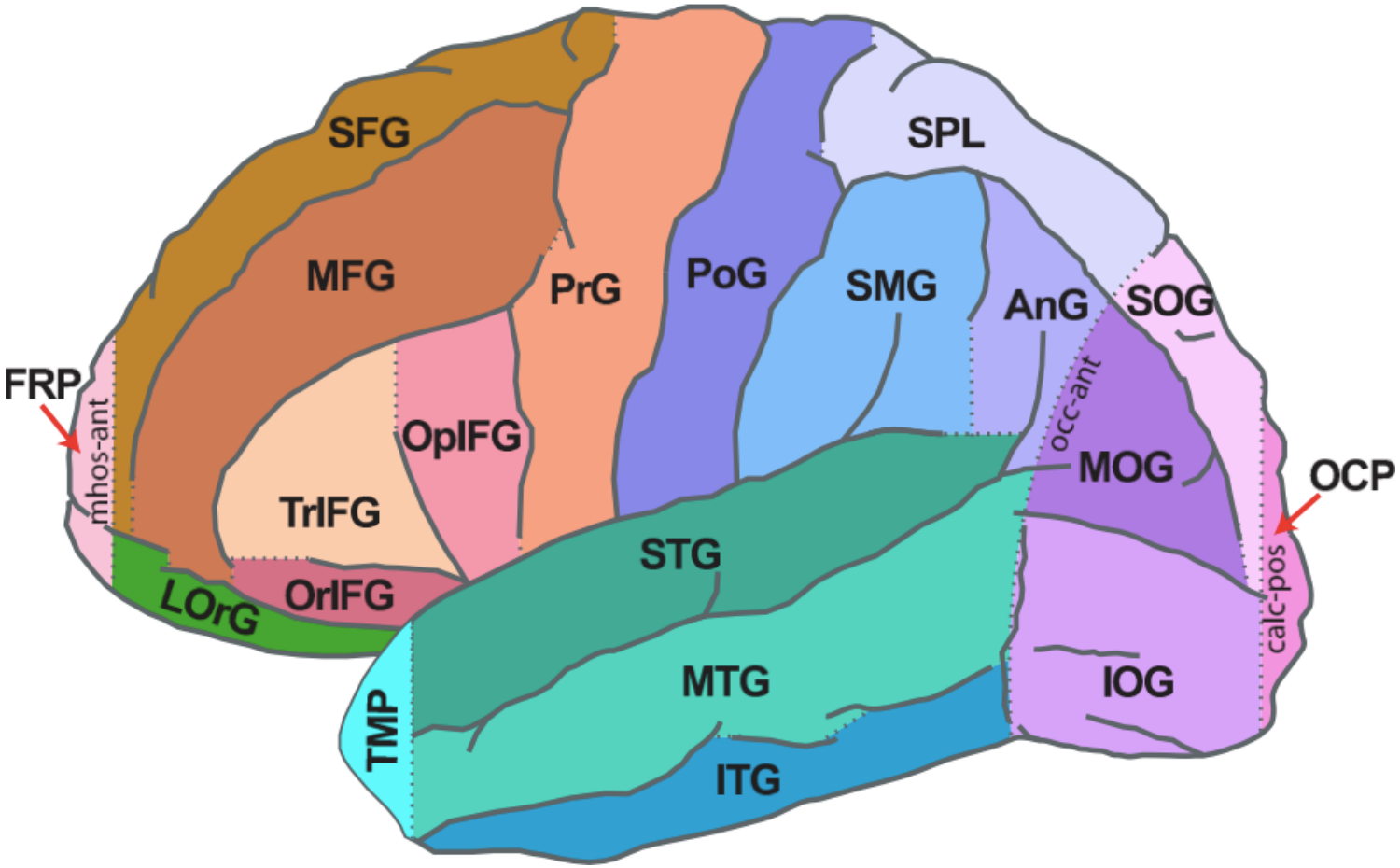

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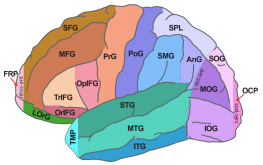

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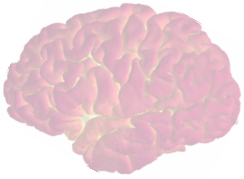

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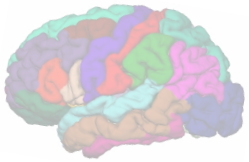

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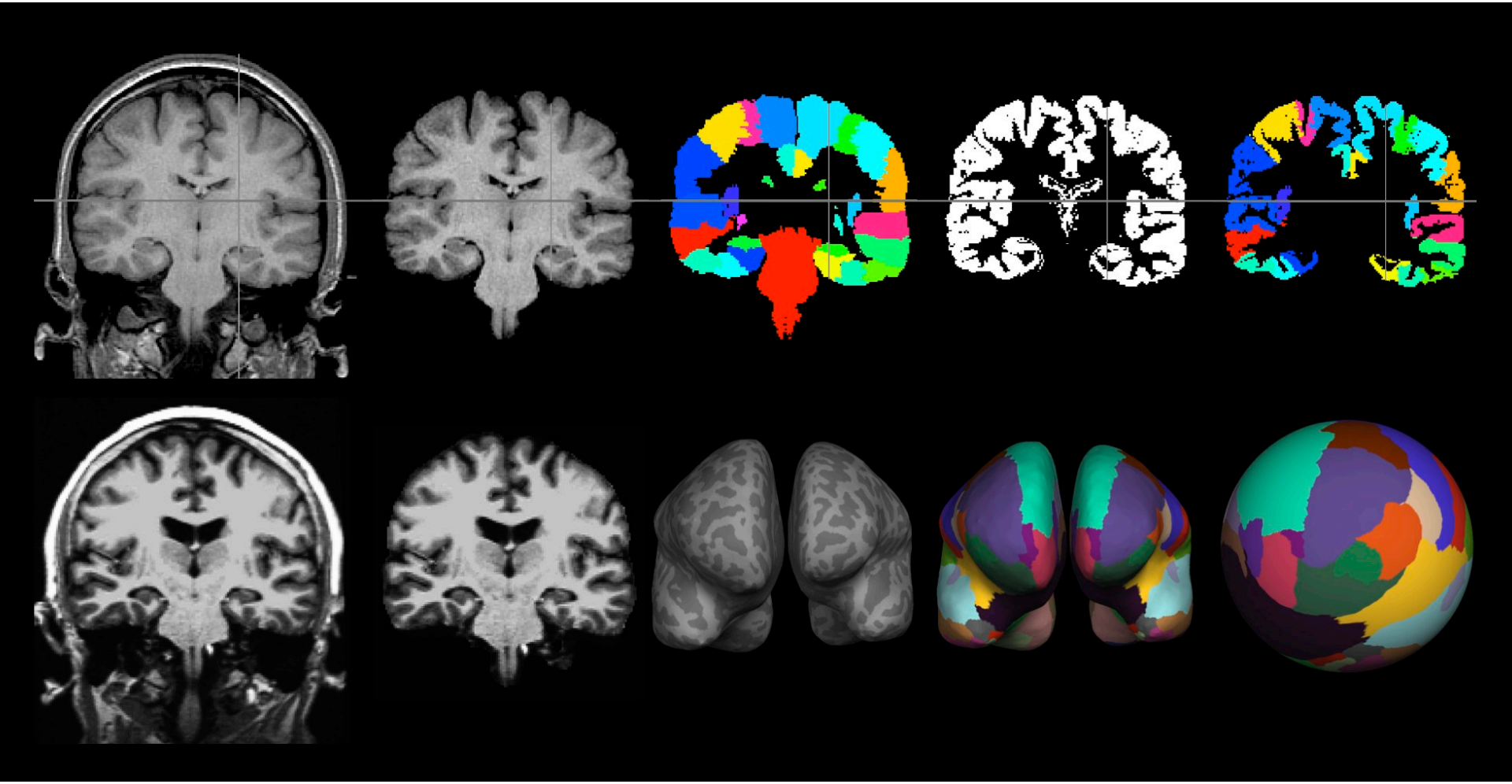
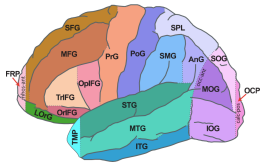


Volume and surface labels



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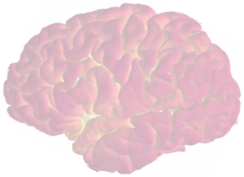

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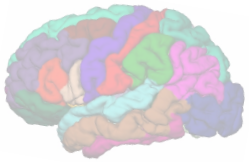

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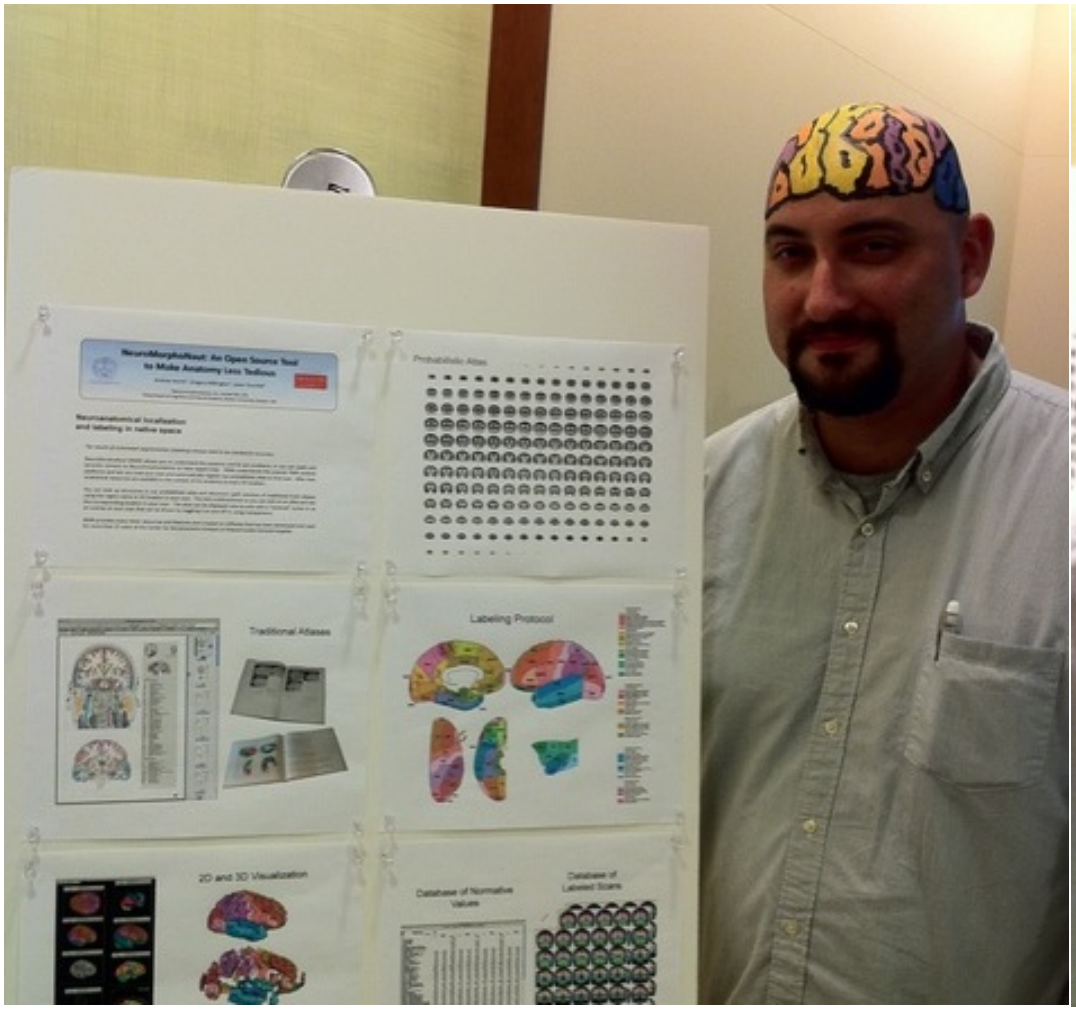
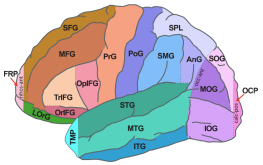


Greg Millington
Neuromorphometrics



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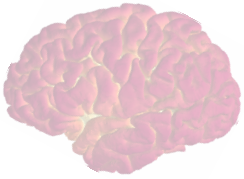
Mindboggle



morphometry

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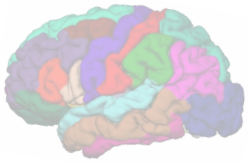


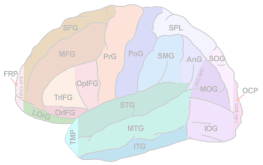
labels

Data sets comprising the Mindboggle-101 labeled data set

Name	Source	N	Age (mean, SD)	Gender		Hand	
				M	F	R	L
NKI-RS-22	"Nathan Kline Institute / Rockland Sample"	22	20-40 (26.0, 5.2)	12	10	21	1
NKI-TRT-24	"Nathan Kline Institute / Test-Retest"	24	21-60 (34.4, 12.6)	18	6	19*	3*
MMRR-21	"Multi-Modal MRI Reproducibility Resource"	21	22-61 (31,8, 9.2)	11	10	18	1
MMRR-3T7T-2	2 3T/7T subjects acquired after the MMRR-21 subjects	2	22, 24	2	0	2	0
HLN-12	"Human Language Network" study subjects	12	23-39 (27.8, 4.6)	6	6	12	0
OASIS-TRT-20	"Open Access Series of Imaging Studies" test-retest ("reliability") sample	20	19-34 (23.4, 3.9)	8	12	20	0

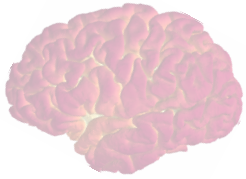
NKI-RS-22	http://fcon_1000.projects.nitrc.org/indi/pro/nki.html
NKI-TRT-24	http://fcon_1000.projects.nitrc.org/indi/pro/eNKI_RS_TRT/FrontPage.html
MMRR-21	http://www.nitrc.org/projects/multimodal
MMRR-3T7T-2	http://www.nitrc.org/projects/multimodal
HLN-12	https://masi.vuse.vanderbilt.edu/public/plos12.tar.bz2
OASIS-TRT-20	http://www.oasis-brains.org/app/action/BundleAction/bundle/OAS1_RELIABILITY

*(2 ambidextrous)



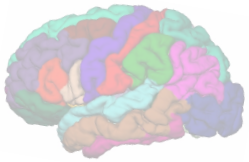
manual

Mindboggle



morphometry

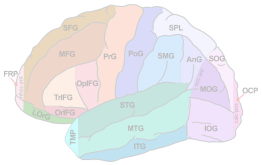
features



labels

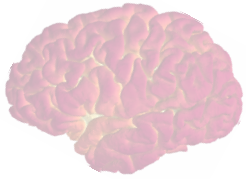
Mindboggle software:

- Python and Python-wrapped C++



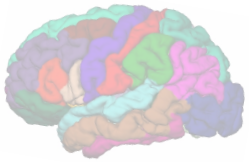
manual

Mindboggle



morphometry

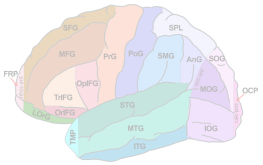
features



labels

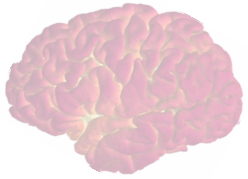
Mindboggle software:

- Python and Python-wrapped C++
- Open source, freely available



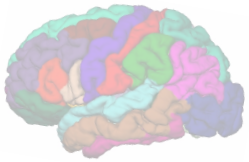
manual

Mindboggle



morphometry

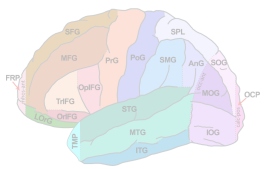
features



labels

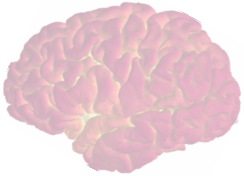
Mindboggle software:

- Python and Python-wrapped C++
- Open source, freely available
- Software pipeline framework



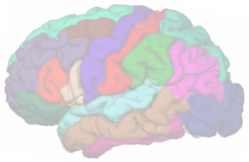
manual

Mindboggle



morphometry

features



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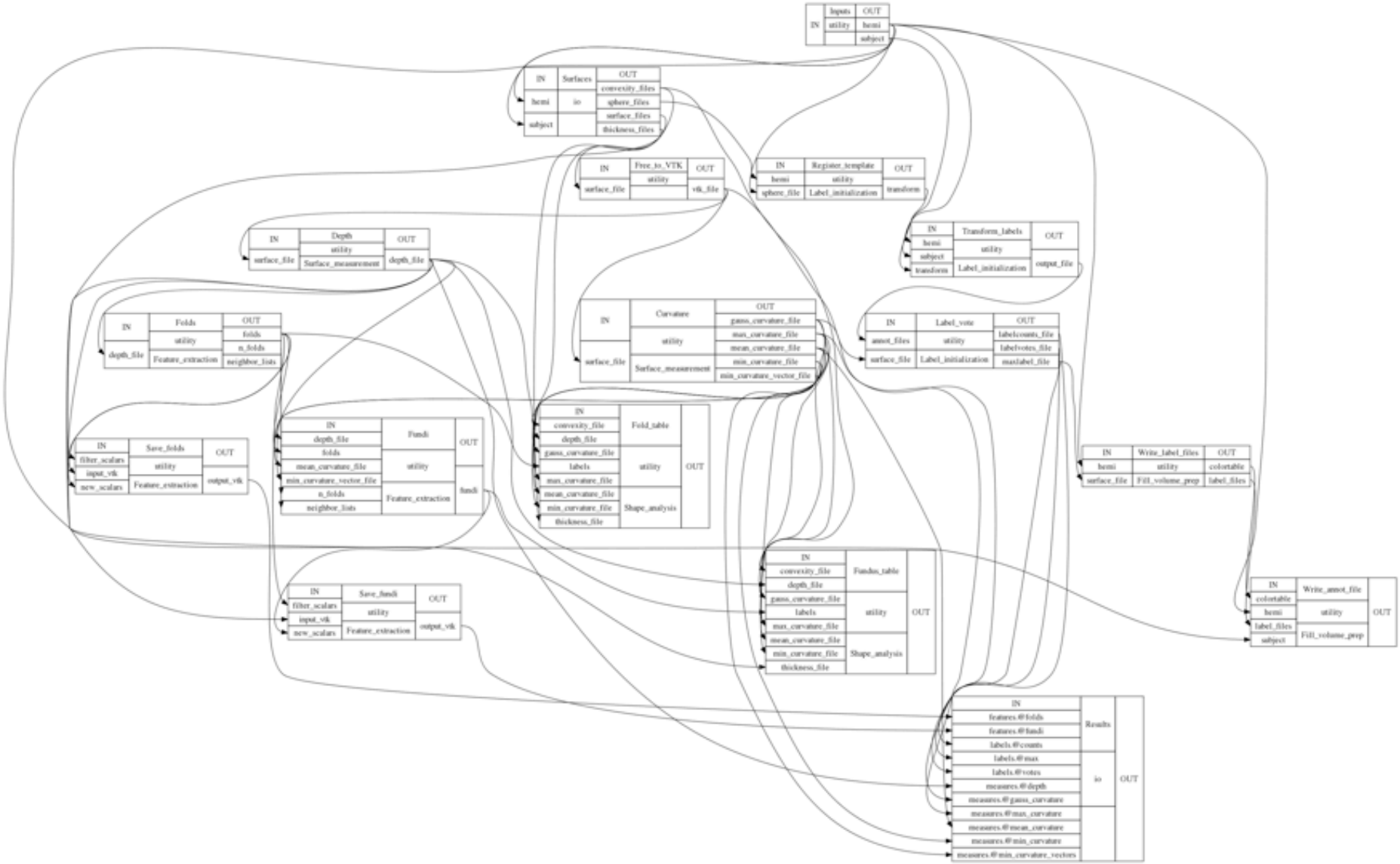
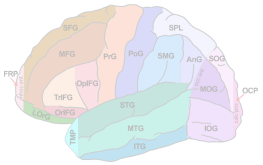
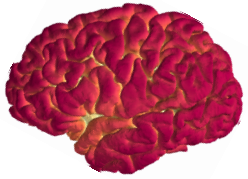




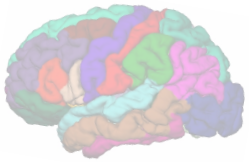
manual

Mindboggle



morphometry

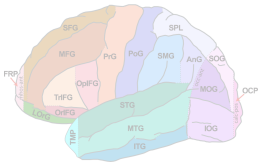
features



labels

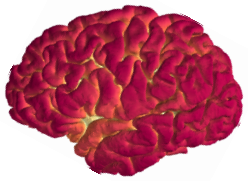
Mindboggle software:

- Morphometry

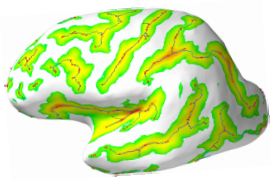


manual

Mindboggle



morphometry



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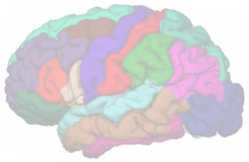
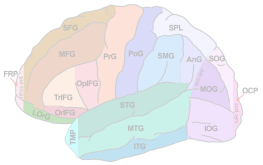


labels

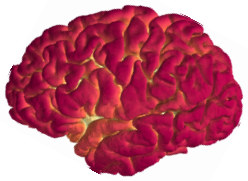
Mindboggle software:

- Morphometry
- Feature extraction and identification

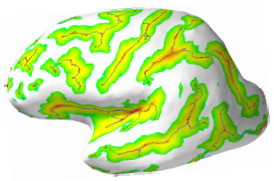


manual

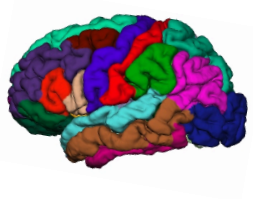
Mindboggle



morphometry



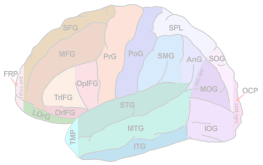
features



labels

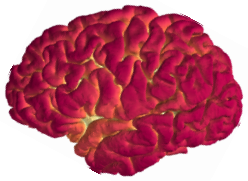
Mindboggle software:

- Morphometry
- Feature extraction and identification
- Labeling



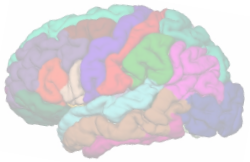
manual

Mindboggle

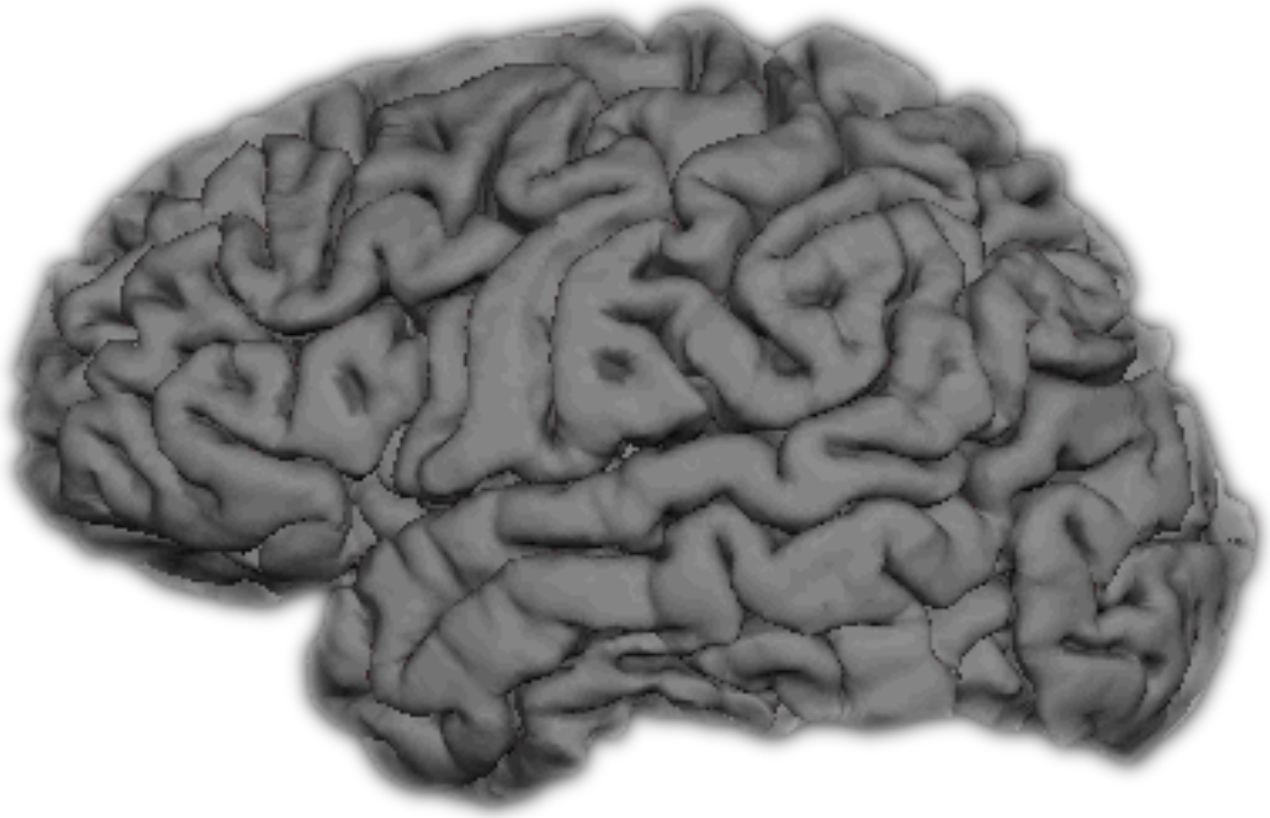


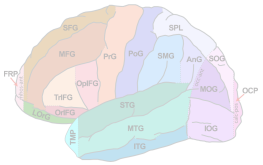
morphometry

features



labels





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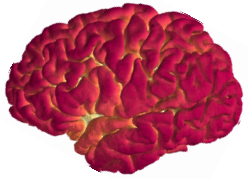
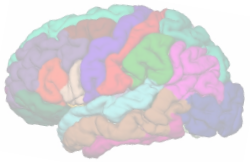
Mindboggle



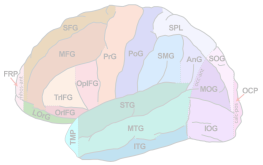
morphometry

features



labels

Mean curvature



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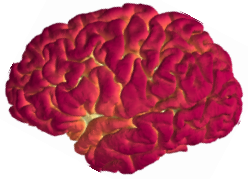
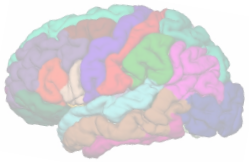
Mindboggle



morphometry

features



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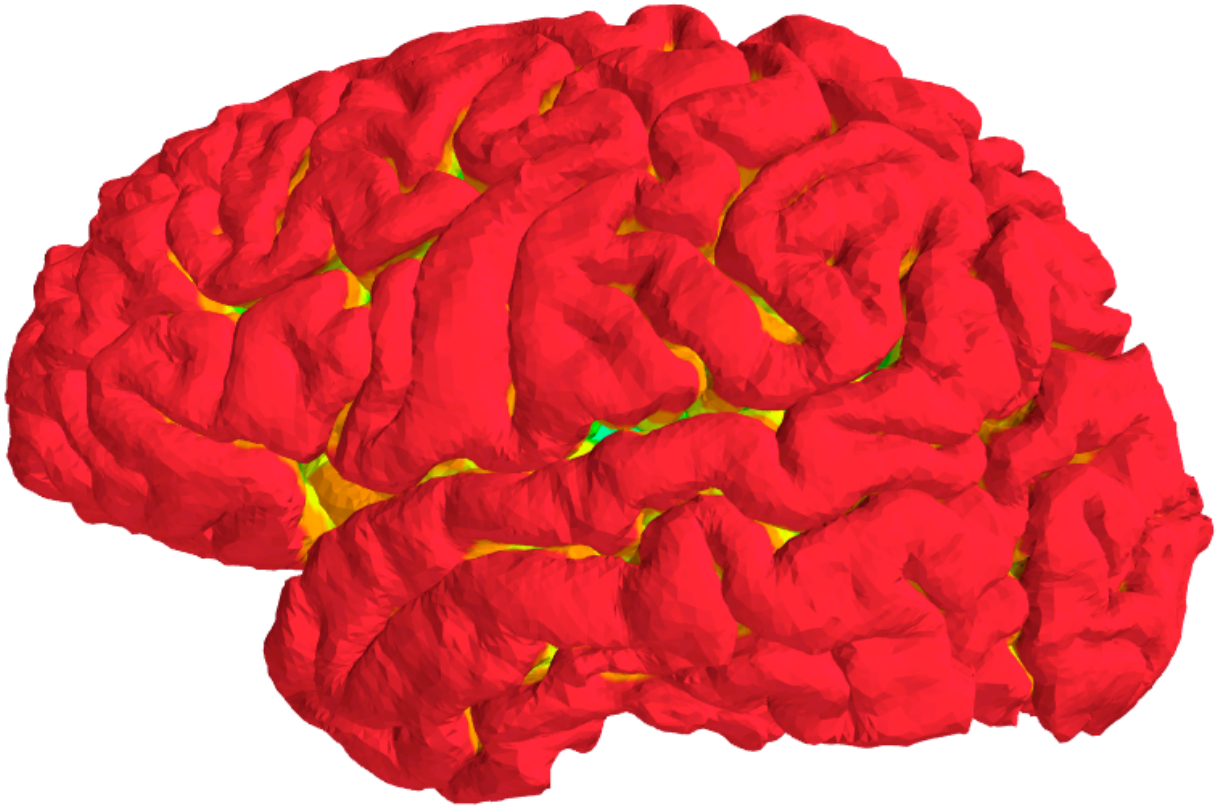
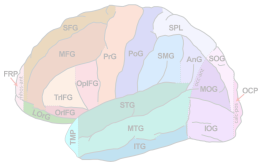


Travel depth



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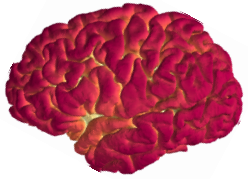
Mindboggle



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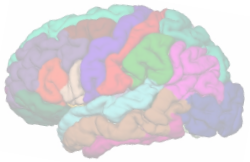

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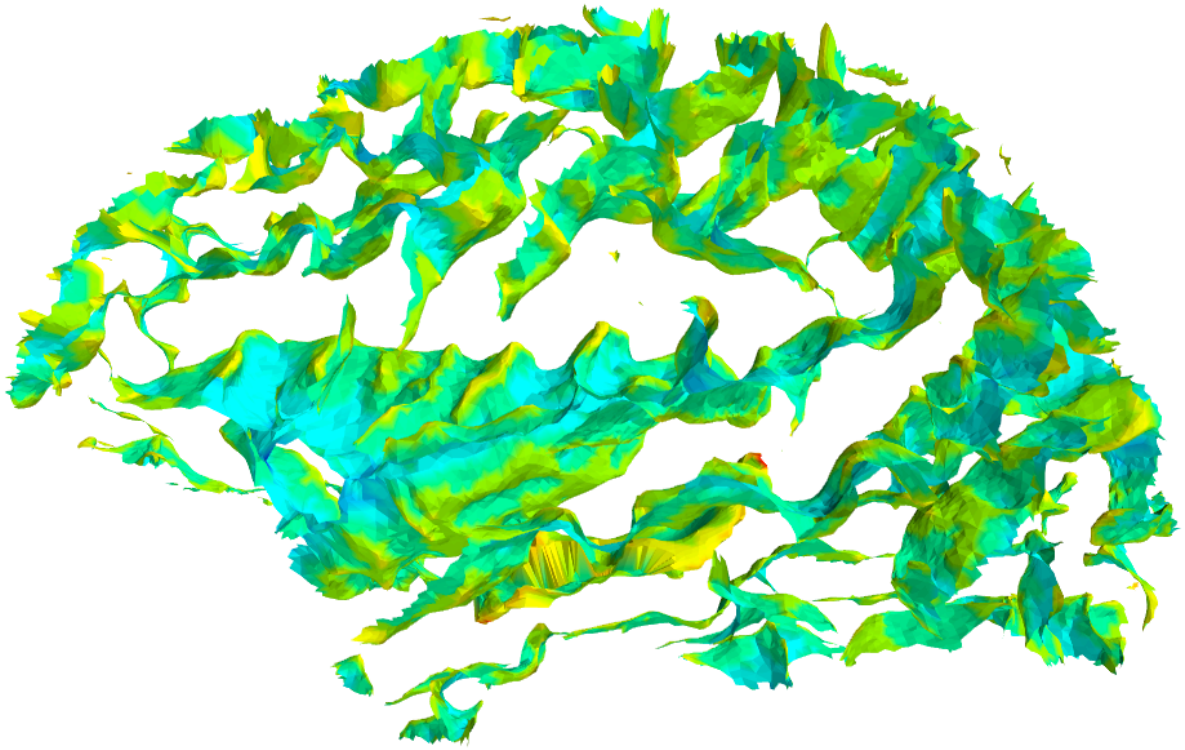
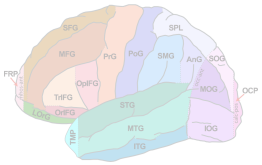
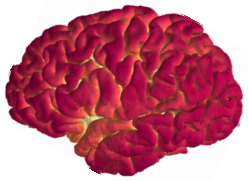


Mean curvature (folds)



manual

Mindboggle



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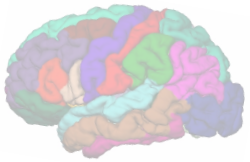

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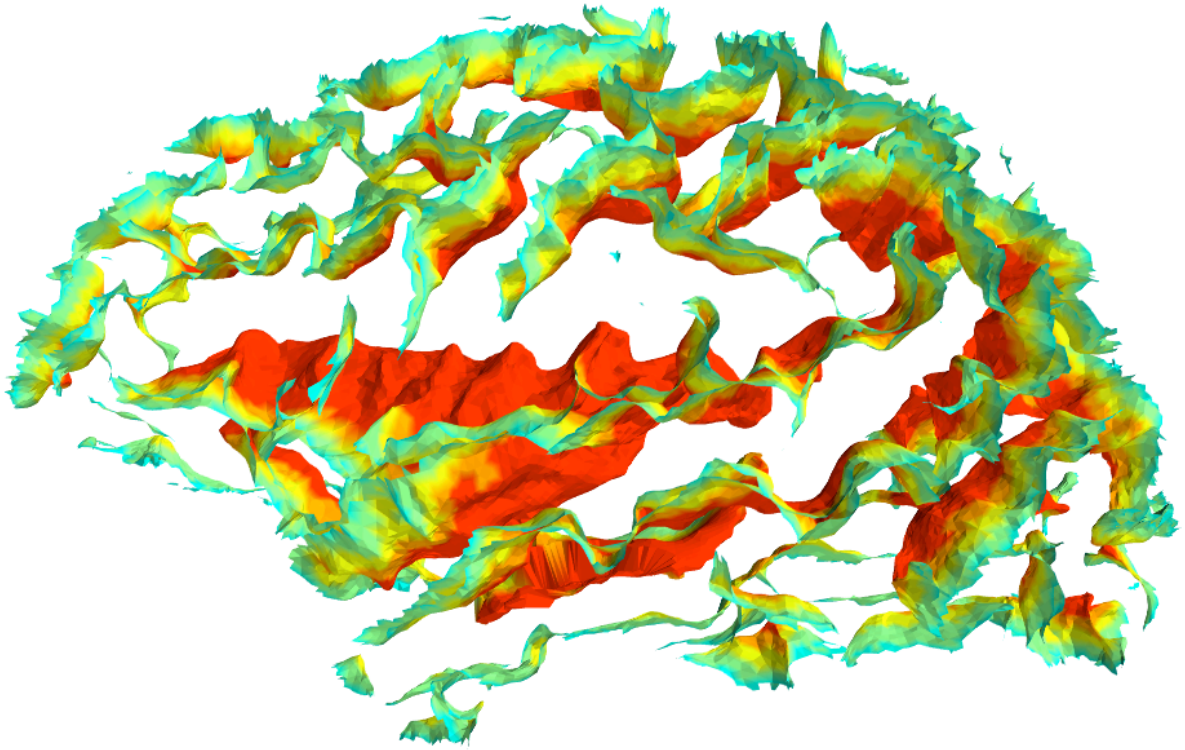
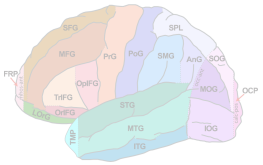
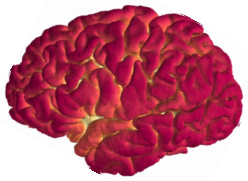


Travel depth (folds)



manual

Mindboggle



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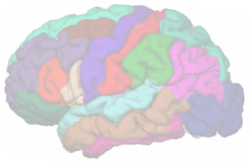

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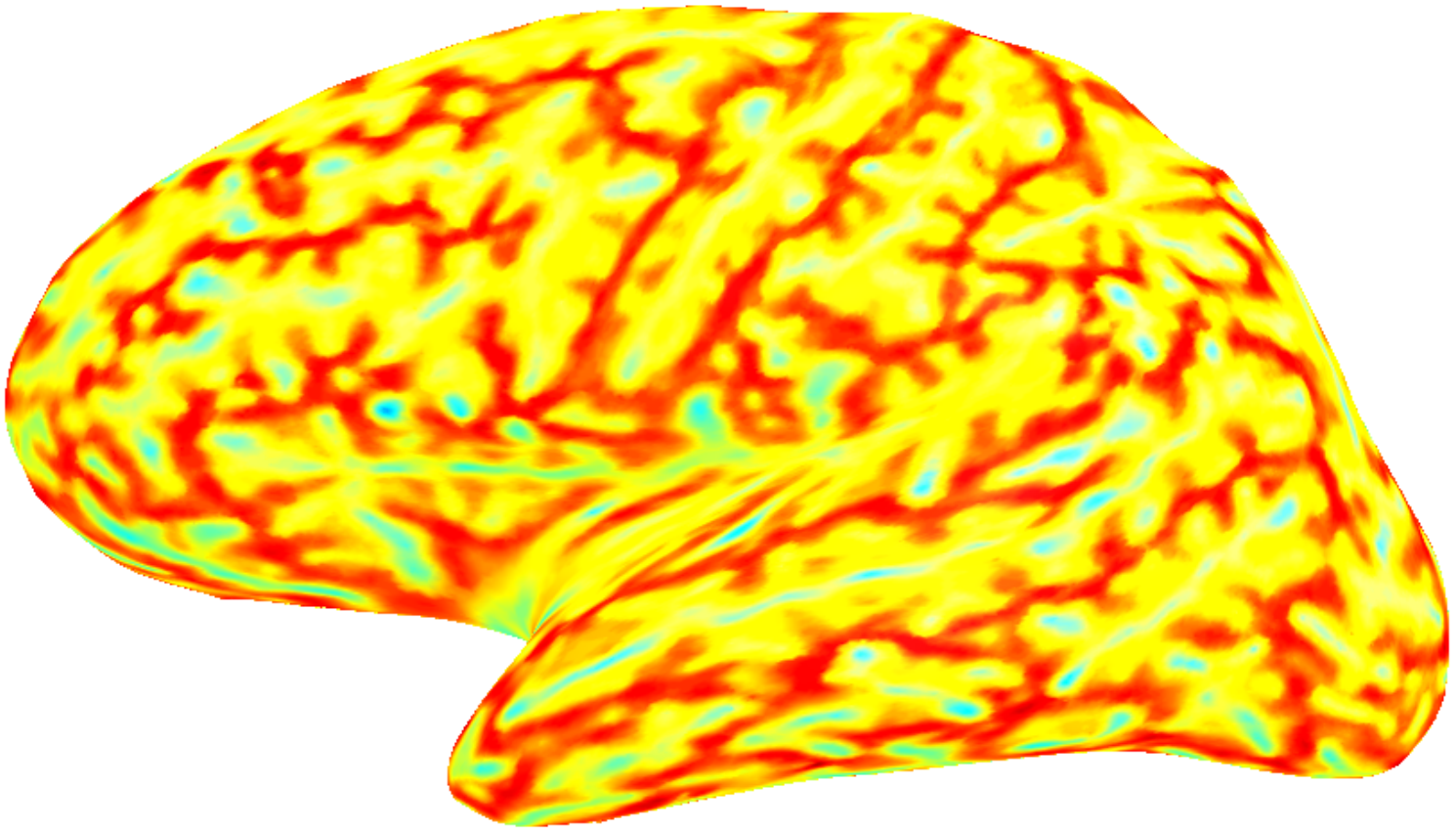
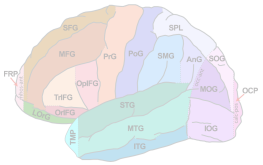


Mean curvature (inflated surface)



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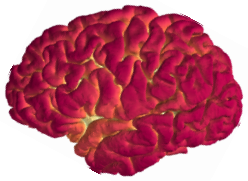
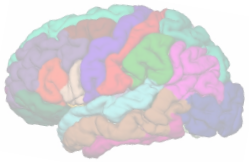
Mindboggle



morphometry

features



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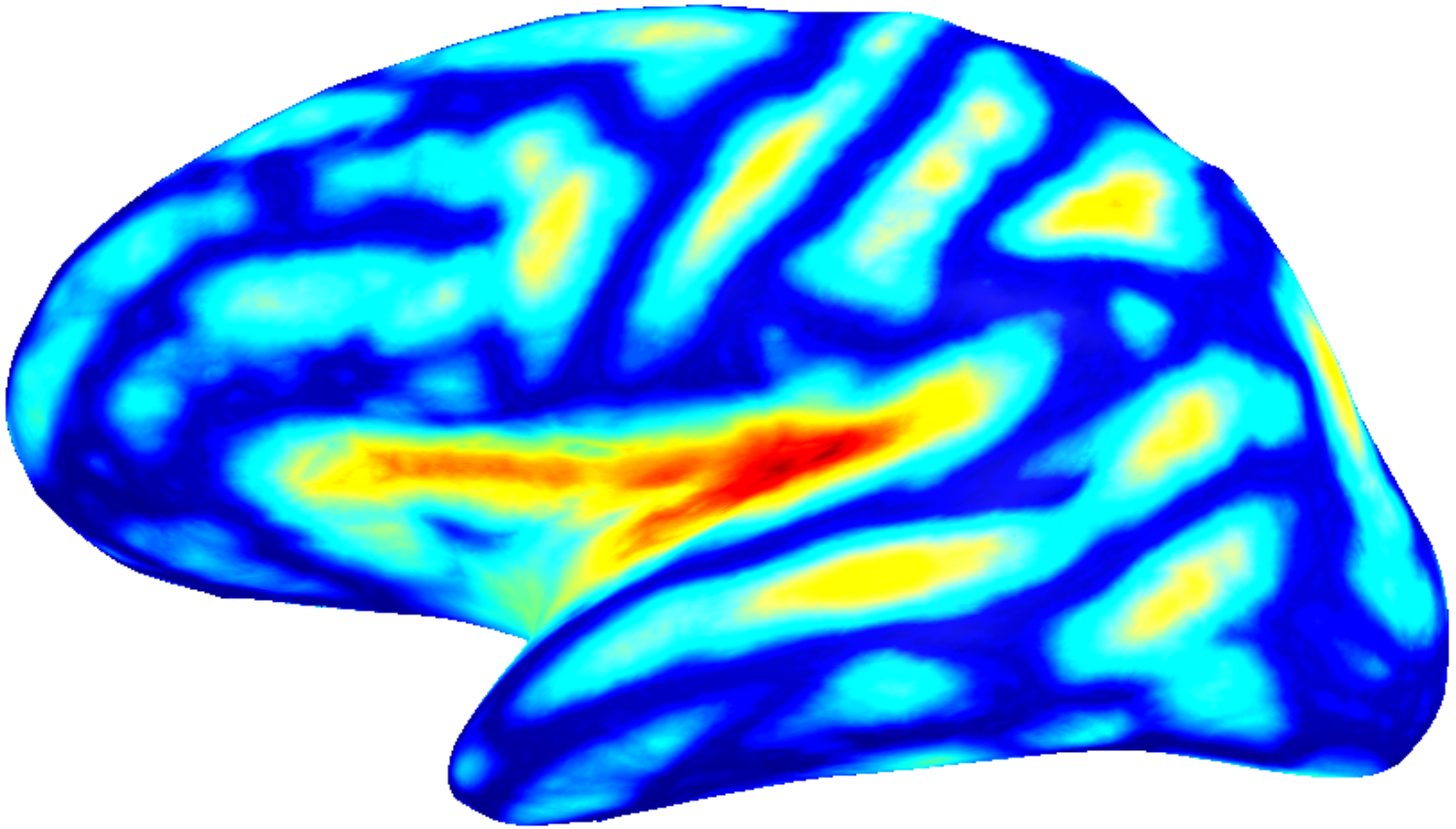
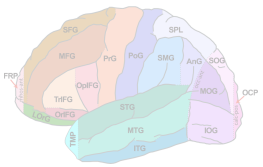
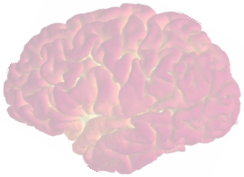


Travel depth (inflated surface)

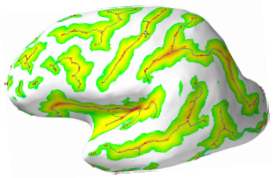


manual

Mindboggle



morphometry



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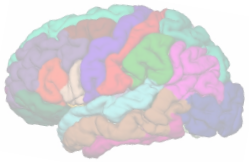

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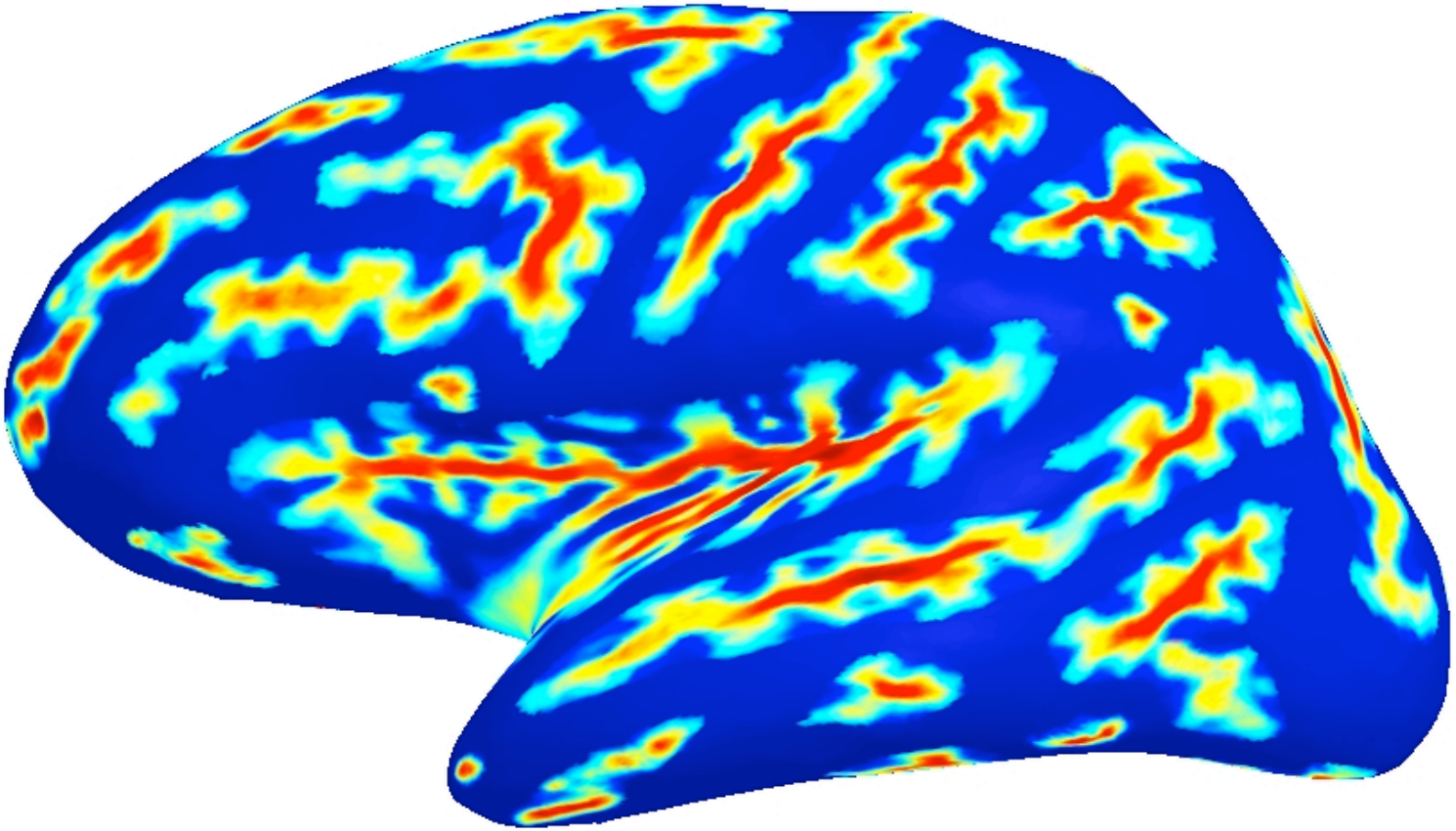
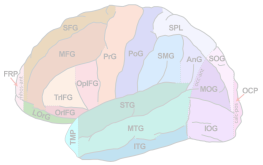
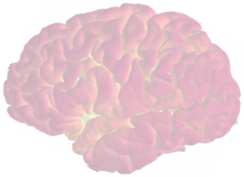


Fundus curves (HMMF)

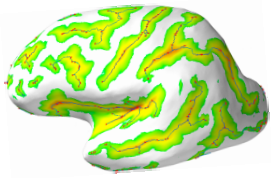


manual

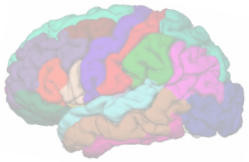
Mindboggle



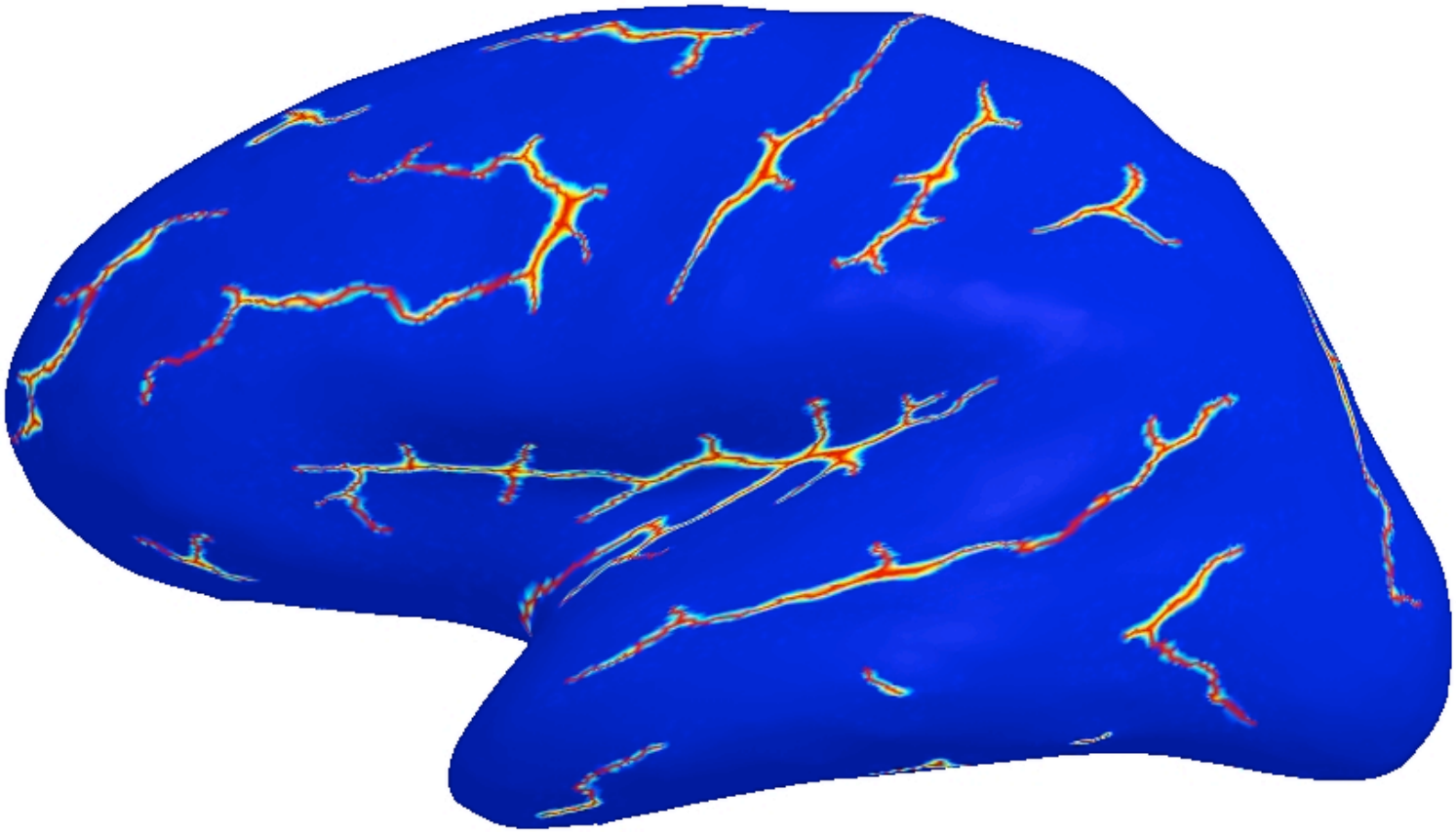
morphometry



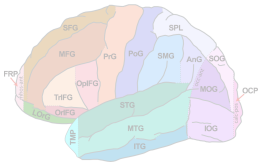
features



labels

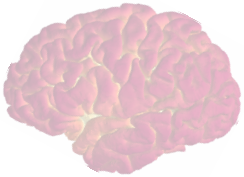


Fundus curves (HMMF)

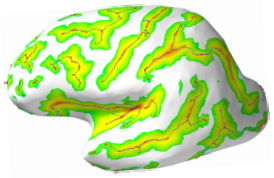


manual

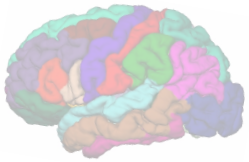
Mindboggle



morphometry



features



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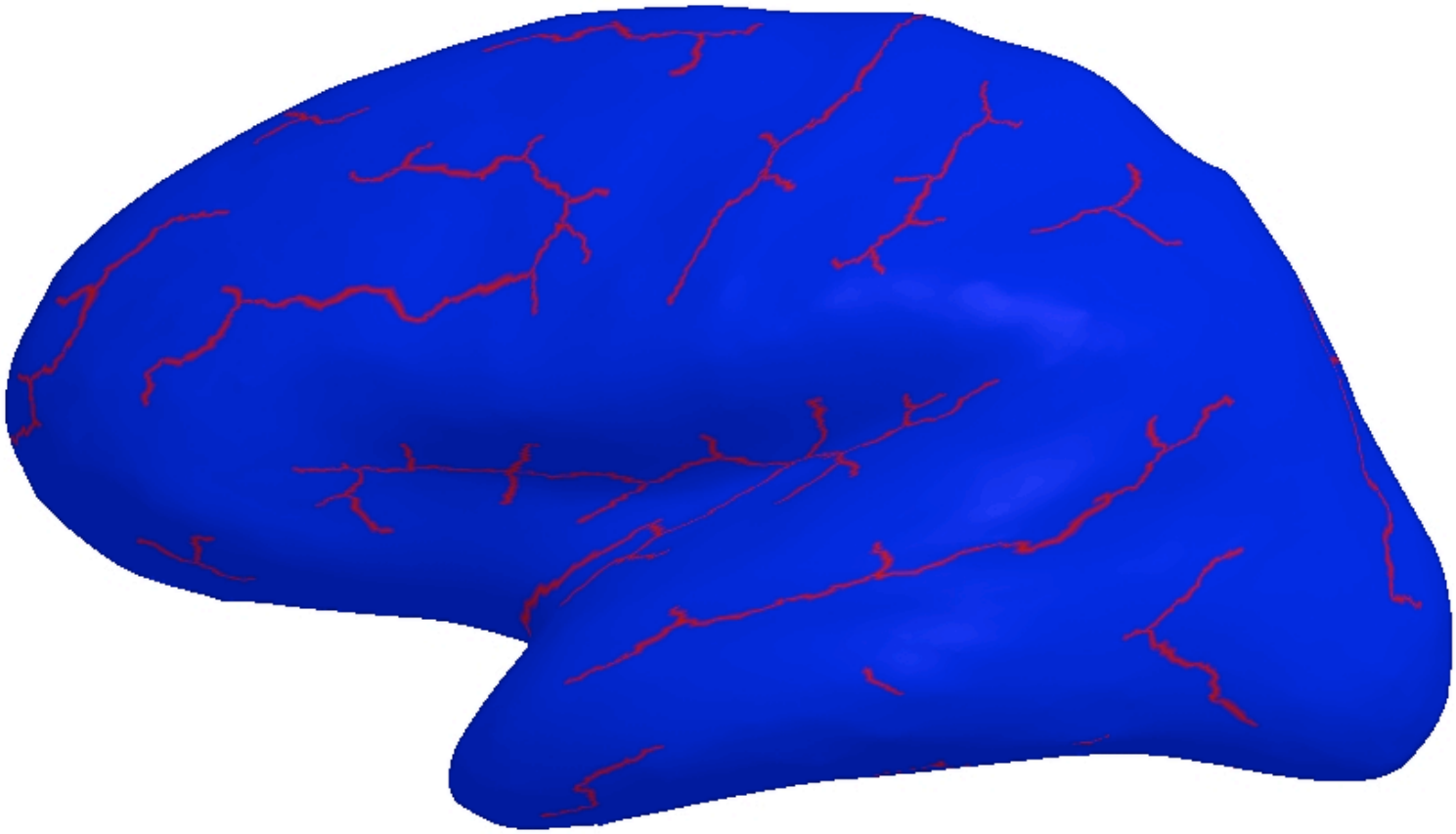
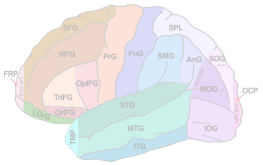
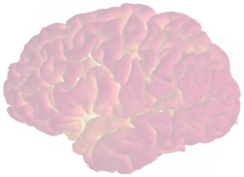


Fundus curves (HMMF)

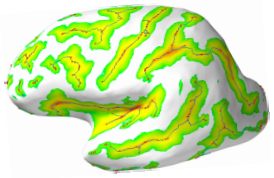


manual

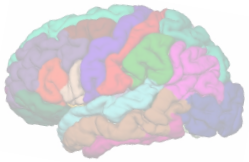
Mindboggle



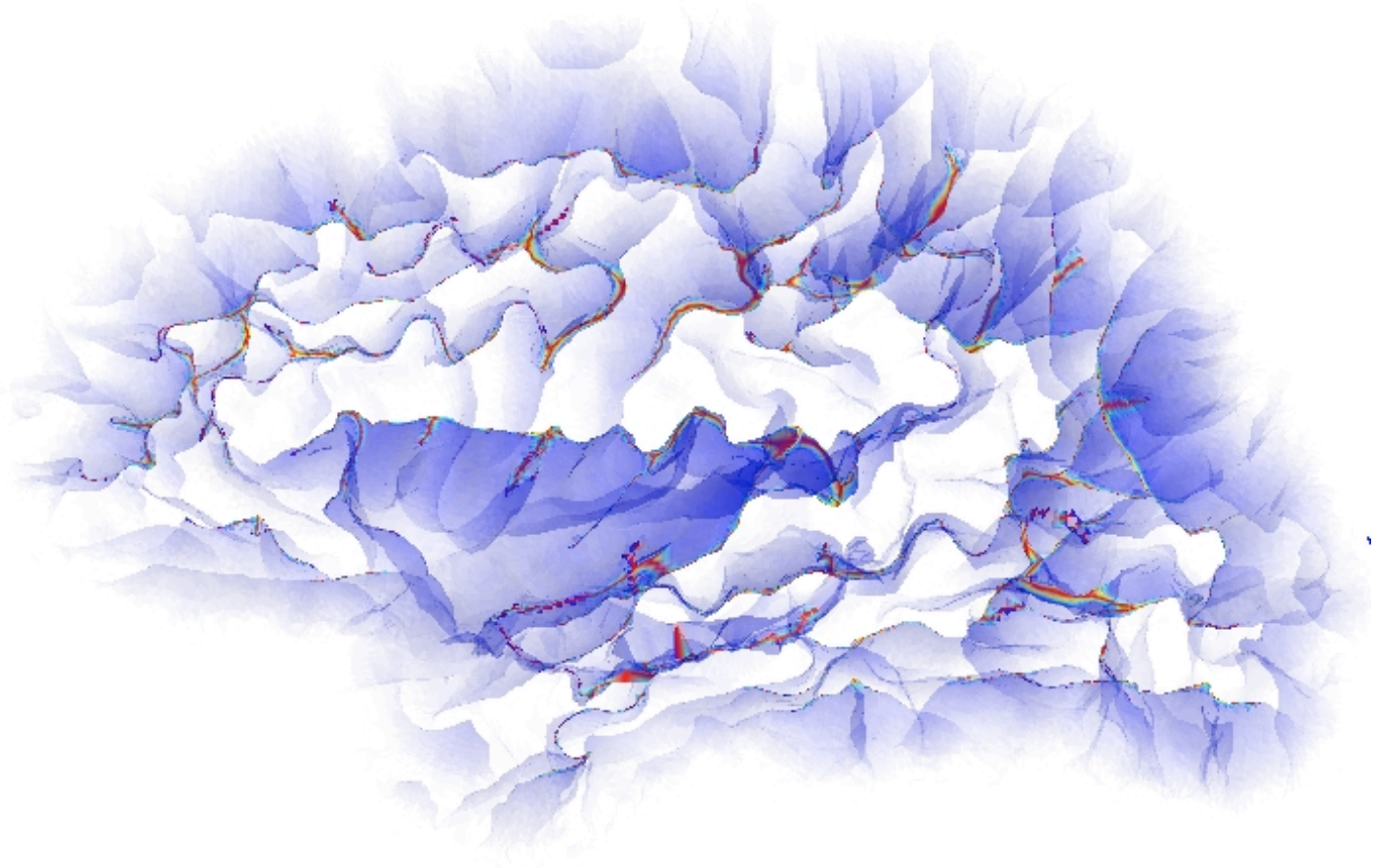
morphometry



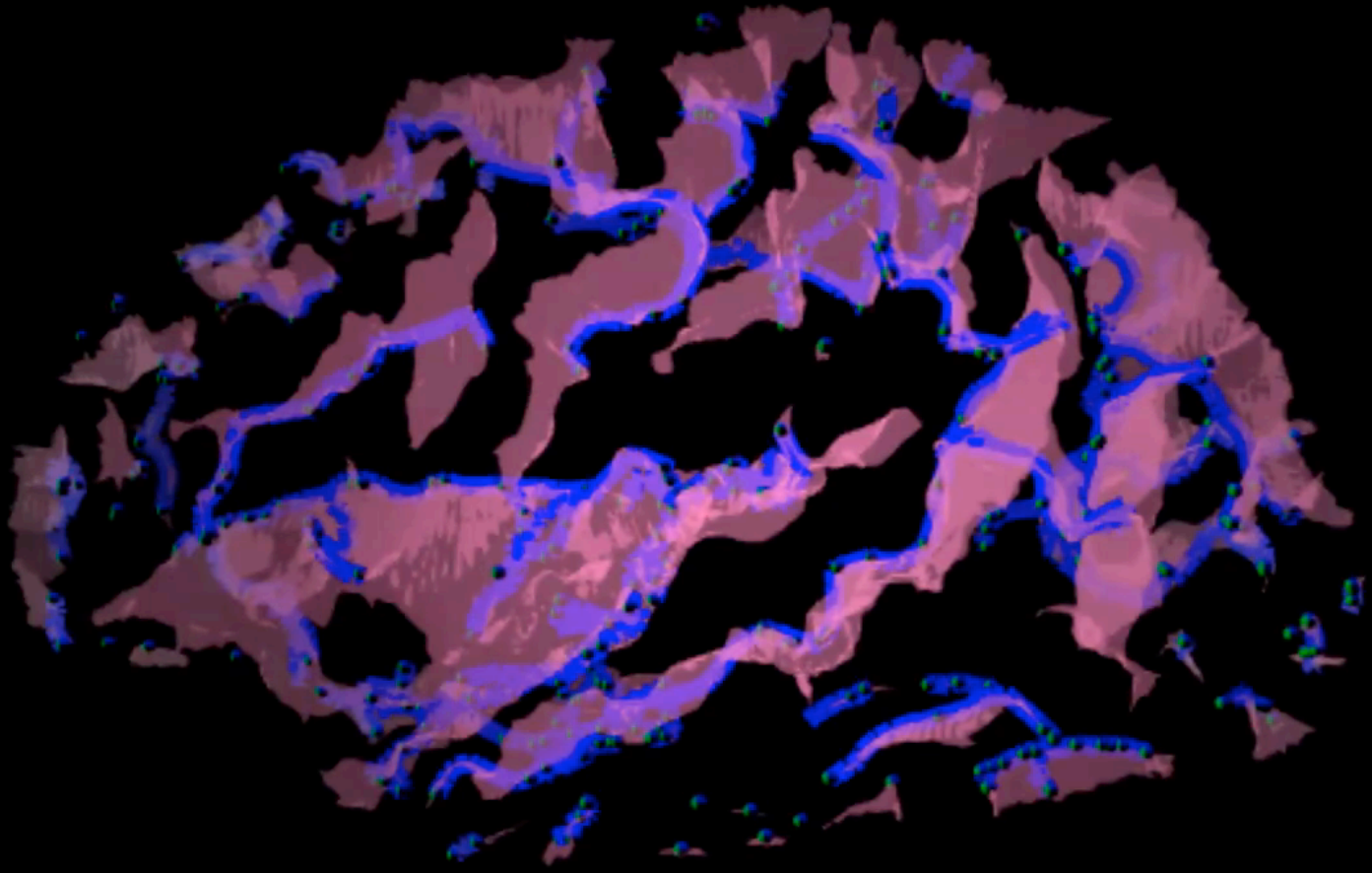
features

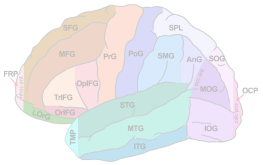


labels



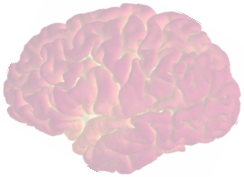
Fundus curves (HMMF)



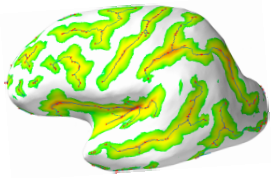


manual

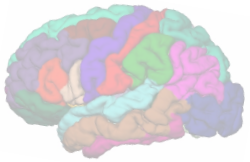
Mindboggle



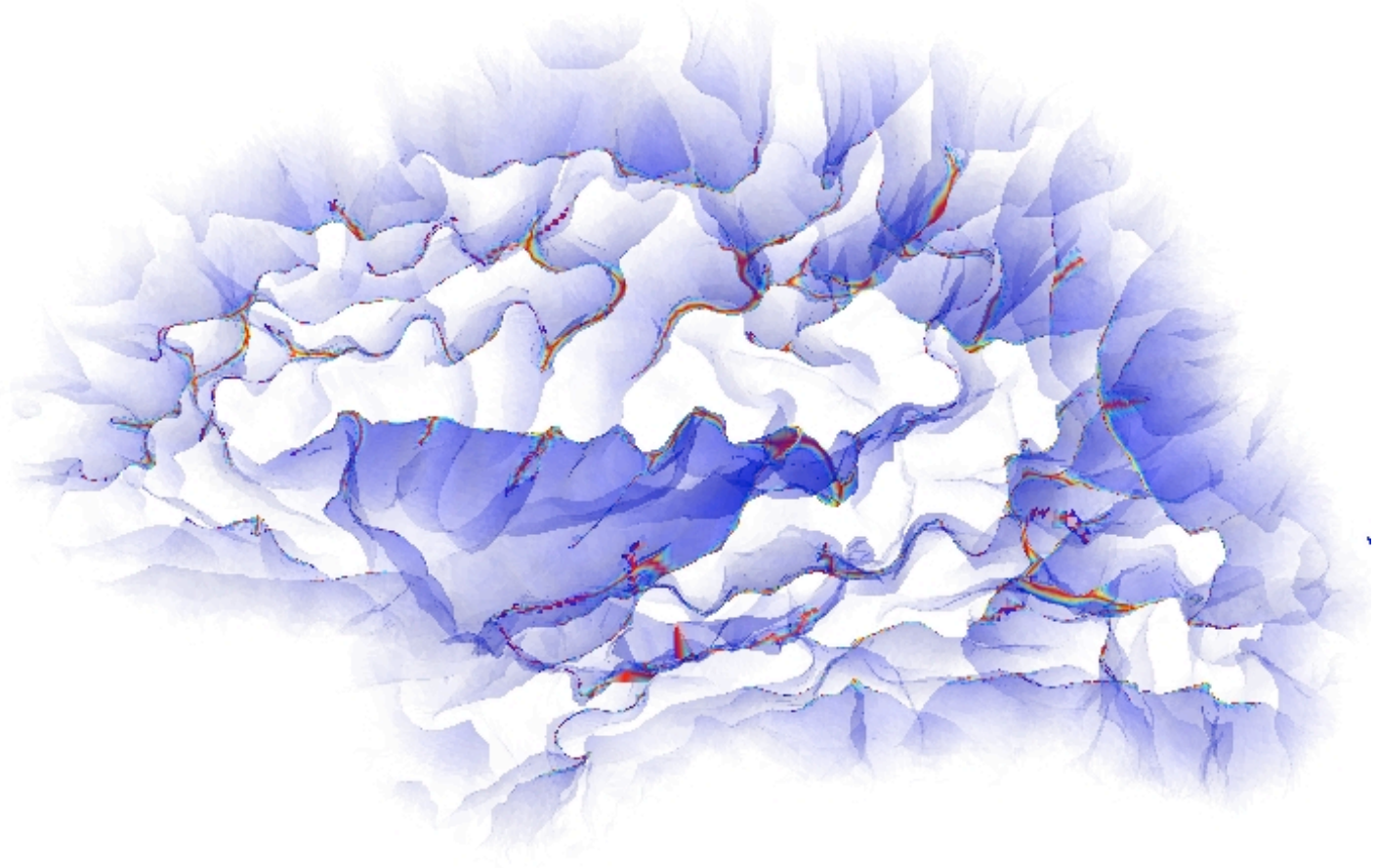
morphometry



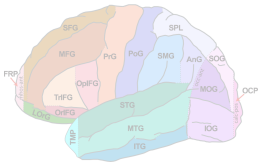
features



labels

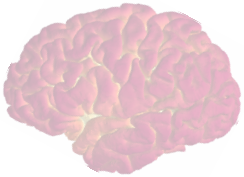


How do we identify features?

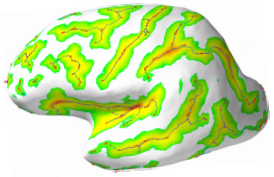


manual

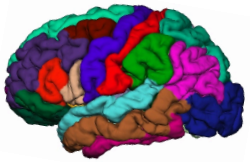
Mindboggle



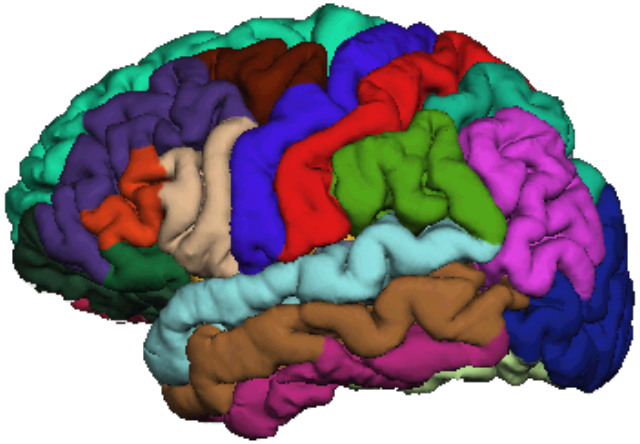
morphometry

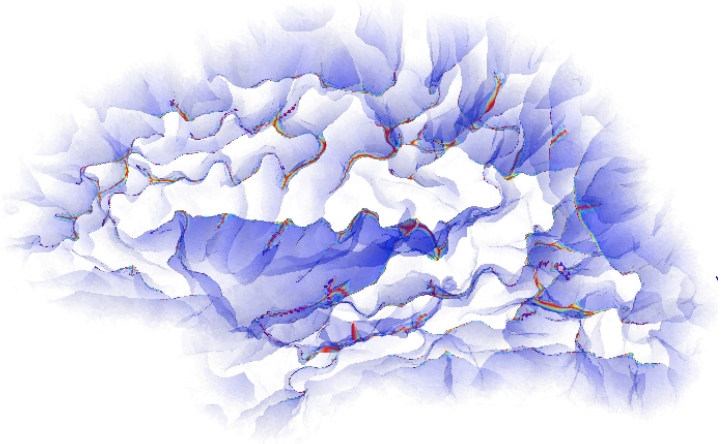


features

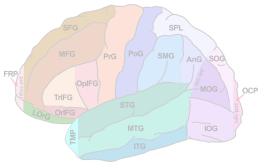


labels



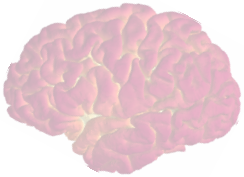


By labels!



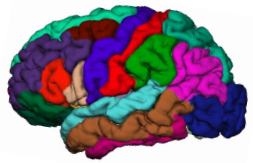
manual

Mindboggle



morphometry

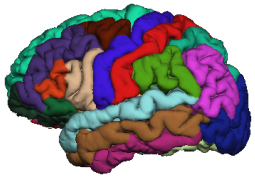
features

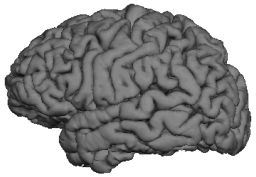


labels

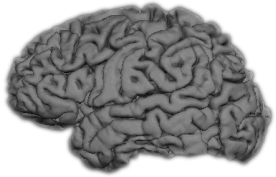
atlas

target



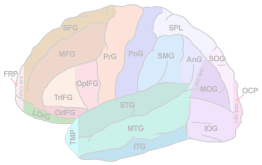


transform



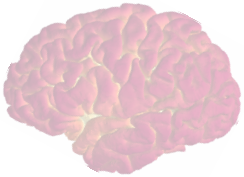
Registration-based labeling:

Step 1: compute registration transform



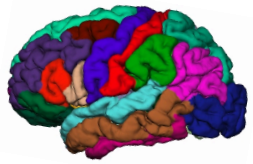
manual

Mindboggle

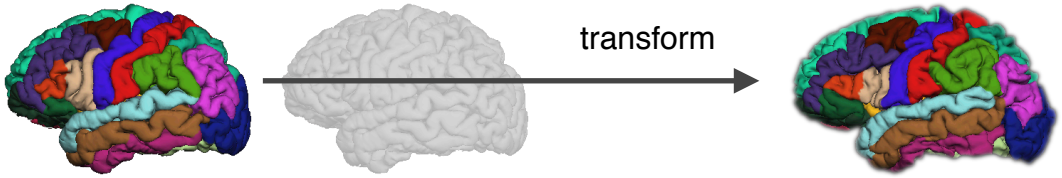


morphometry

features

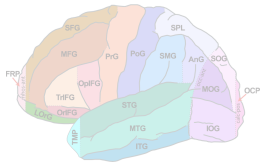


labels



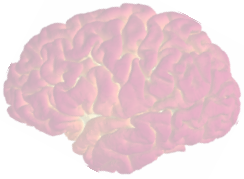
Registration-based labeling:

Step 2: apply transform to atlas labels



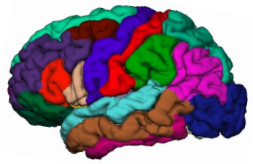
manual

Mindboggle

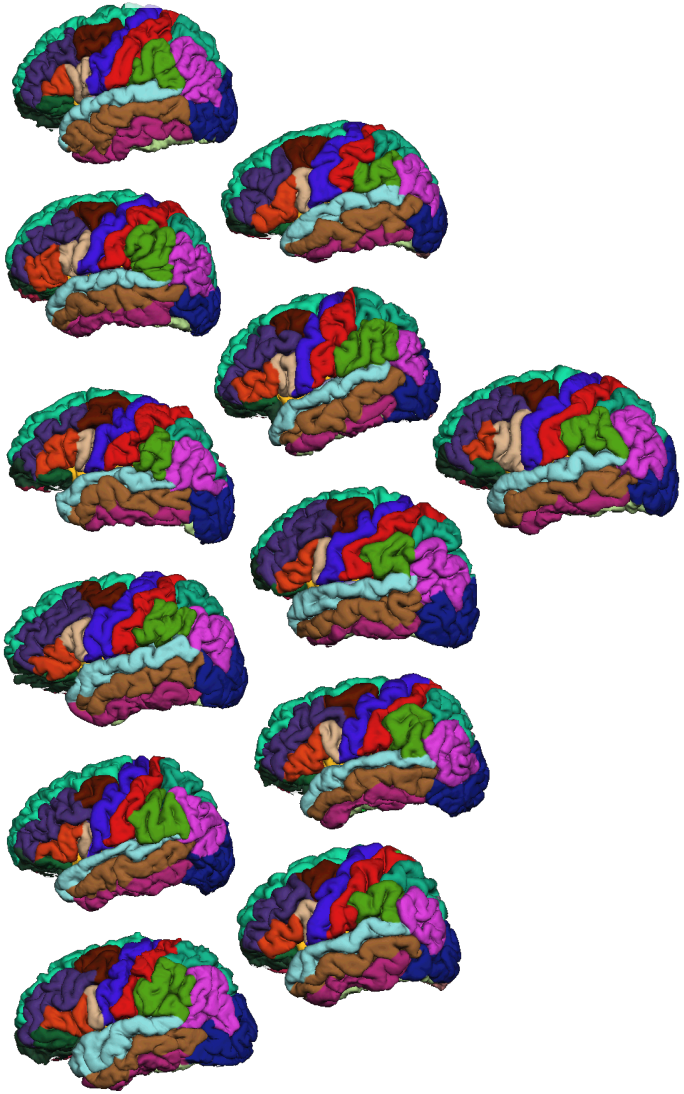


morphometry

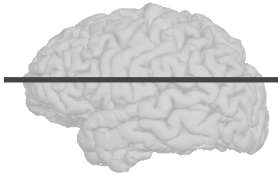
features



labels

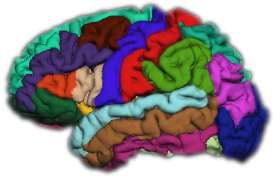


atlases



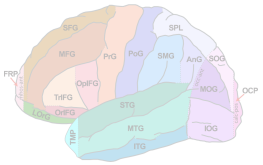
transform

multi-atlas
labeled
target



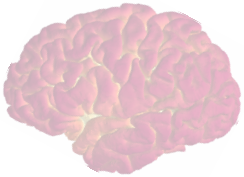
Registration-based labeling:

Step N: repeat for multiple atlases



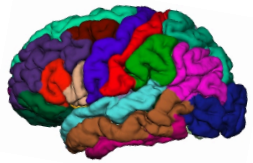
manual

Mindboggle

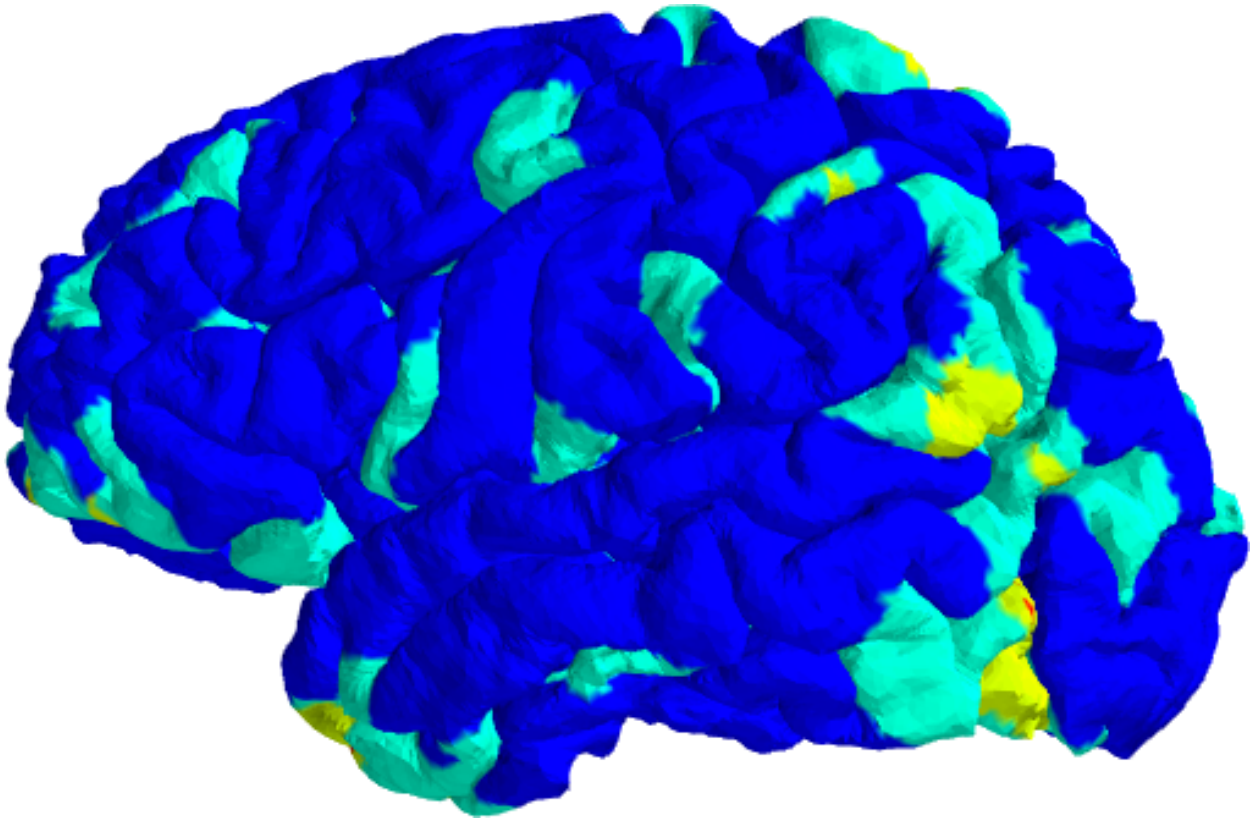


morphometry

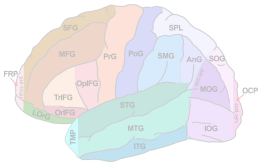
features



labels

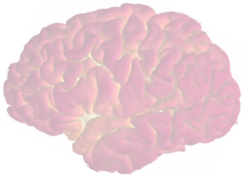


#labels per vertex



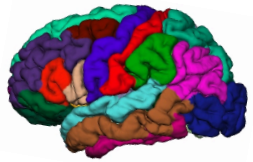
manual

Mindboggle

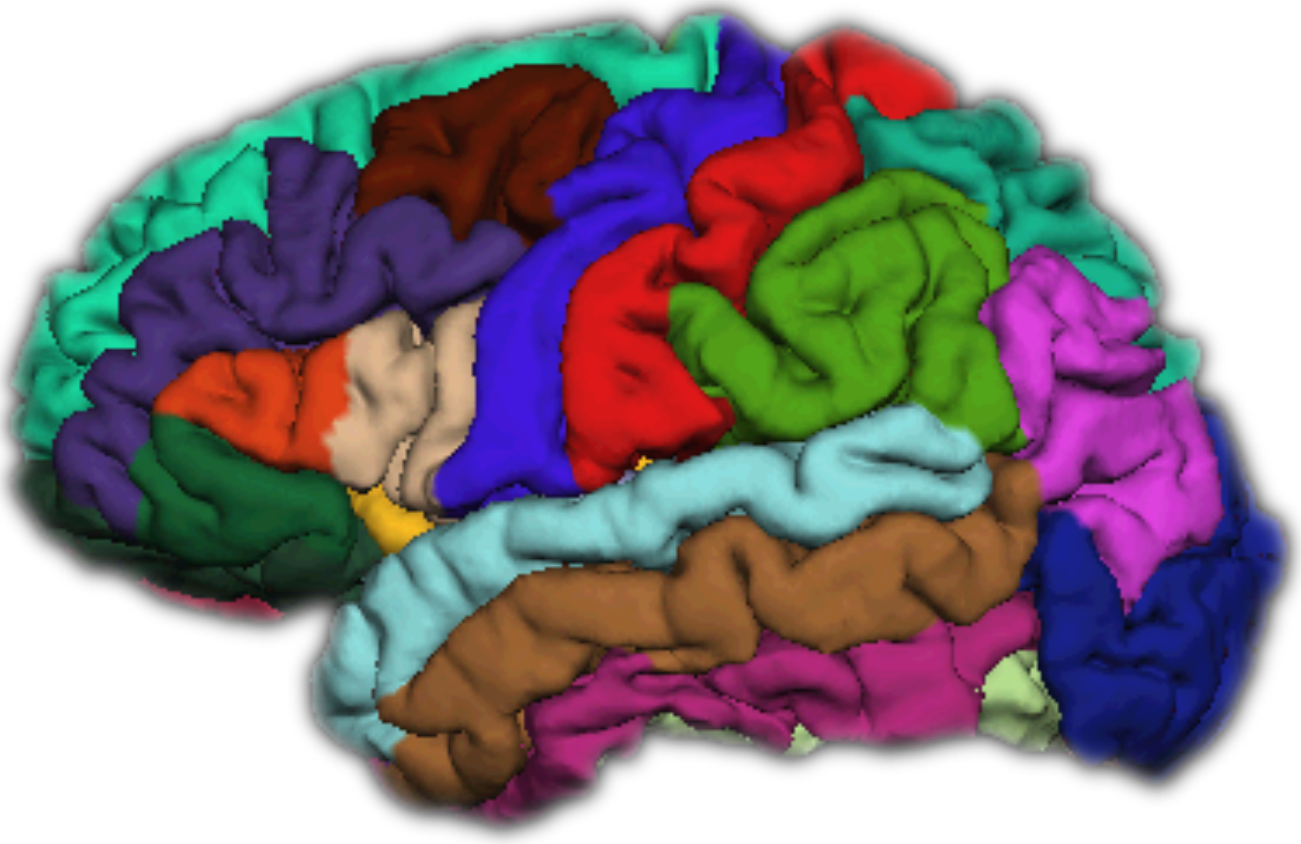


morphometry

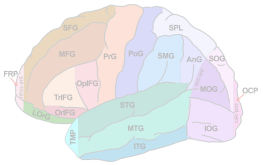
features



labels

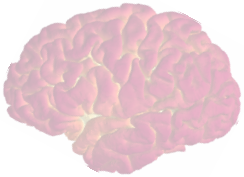


Majority vote labels



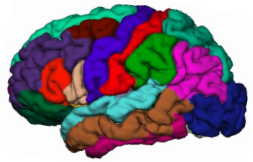
manual

Mindboggle

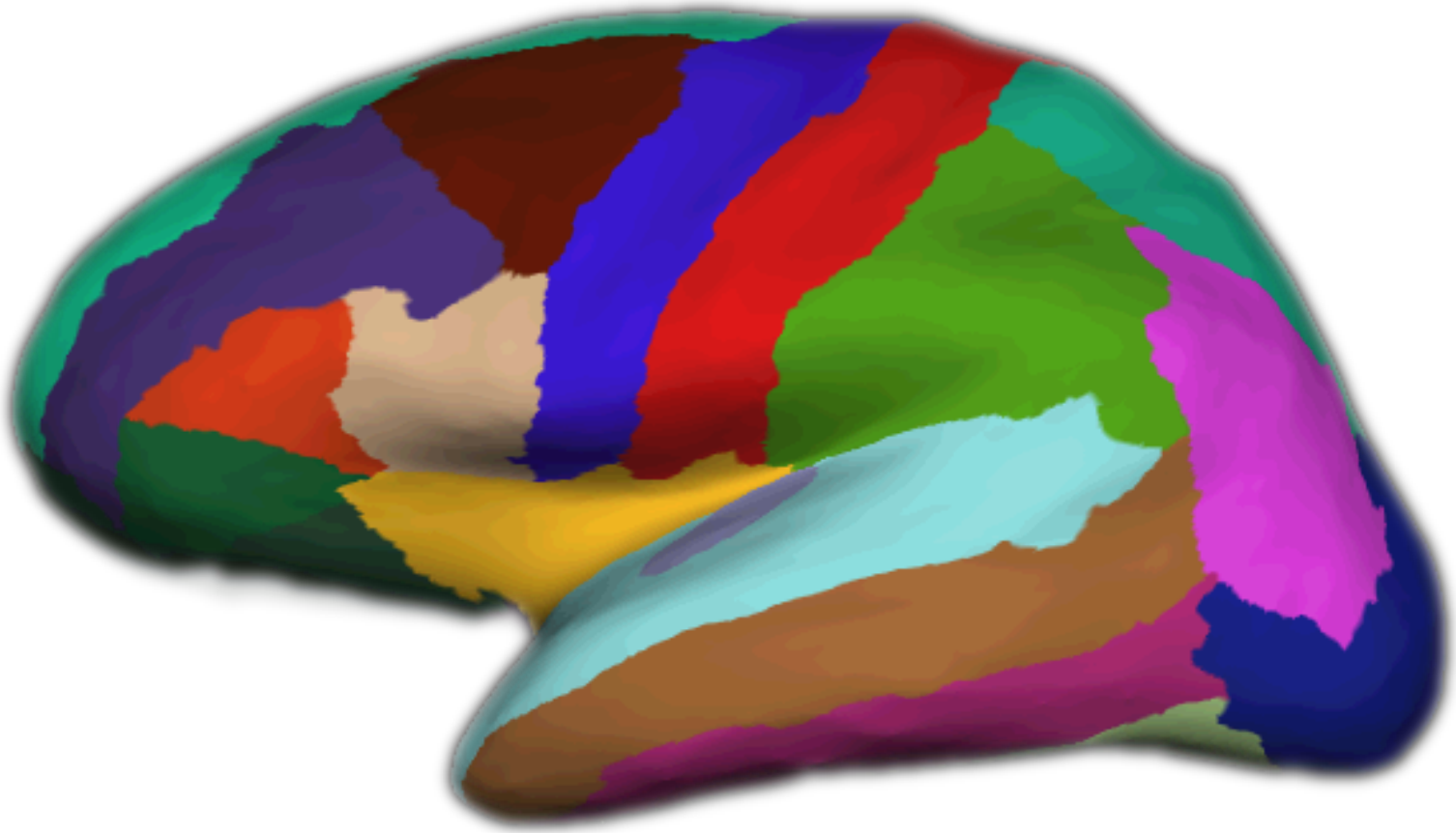


morphometry

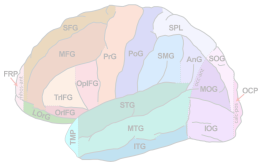
features



labels

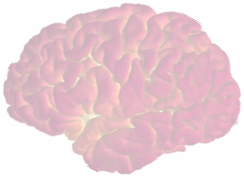


Majority vote labels (inflated)

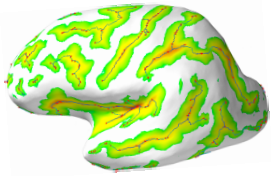


manual

Mindboggle



morphometry



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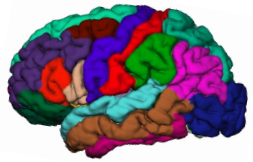

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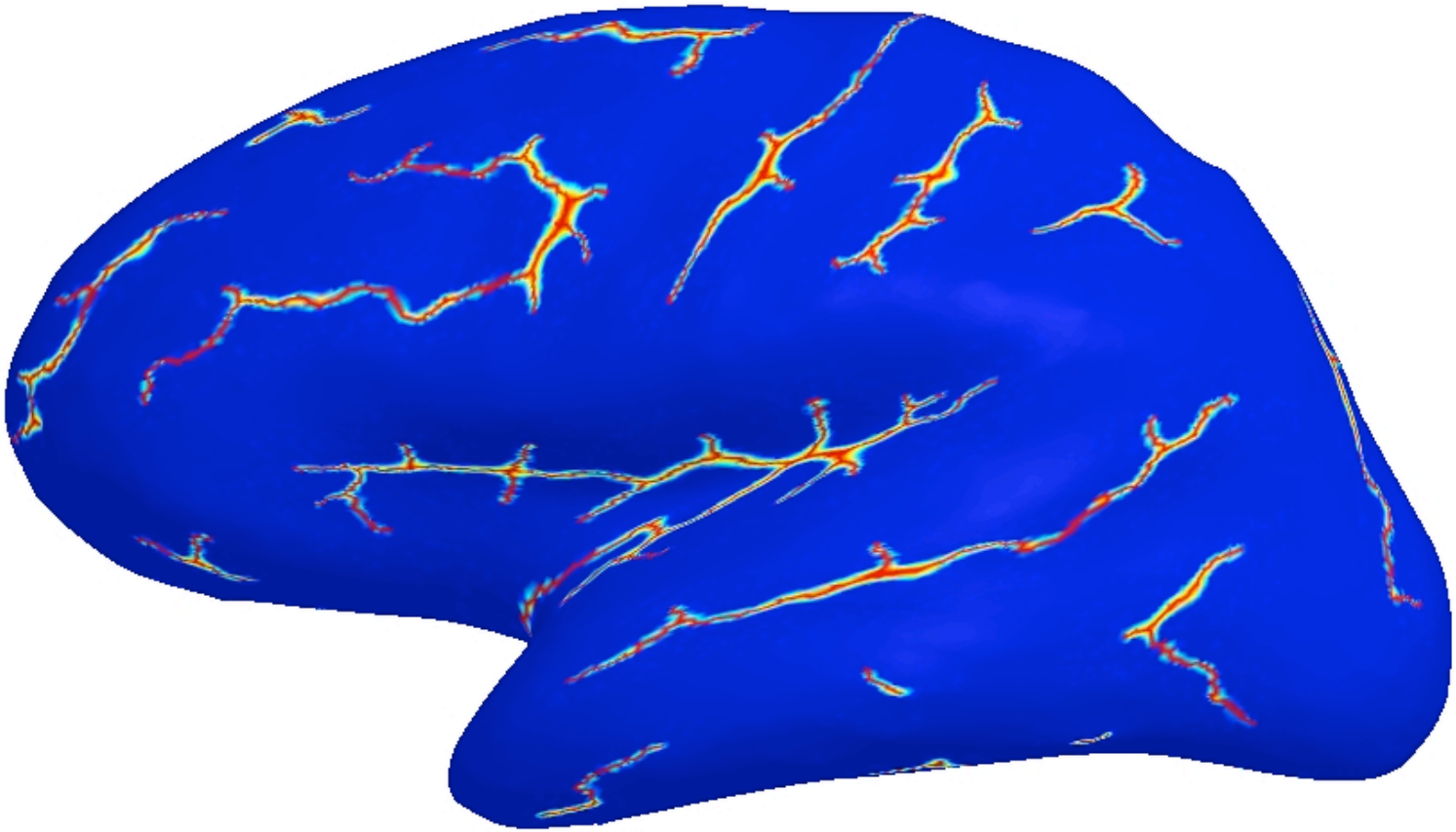
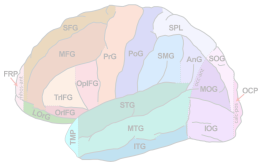
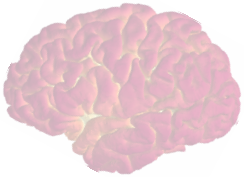


Adjust label boundaries using fundus curves

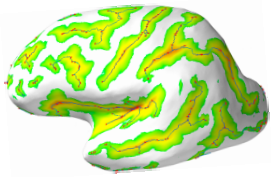


manual

Mindboggle



morphometry



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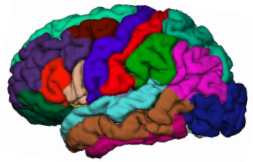

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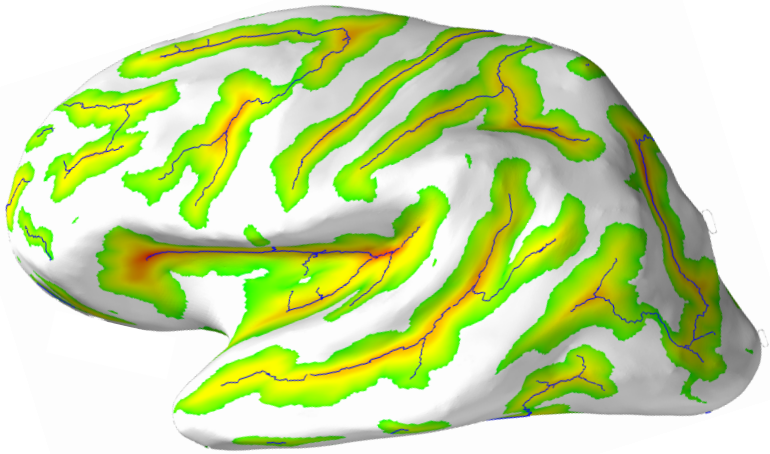
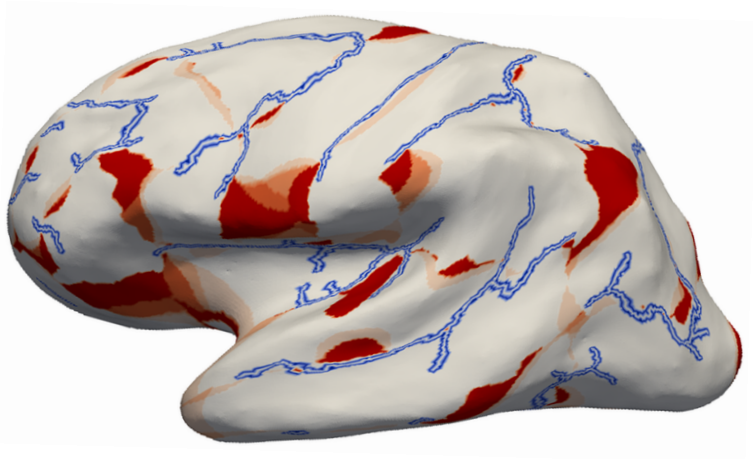
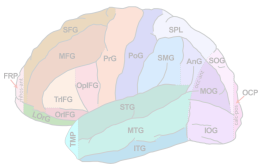


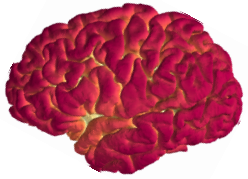


Adjust label boundaries using fundus curves (errors)



manual

Mindboggle



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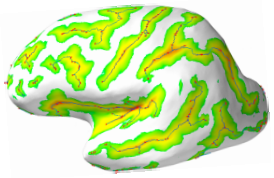

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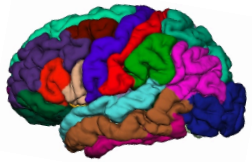

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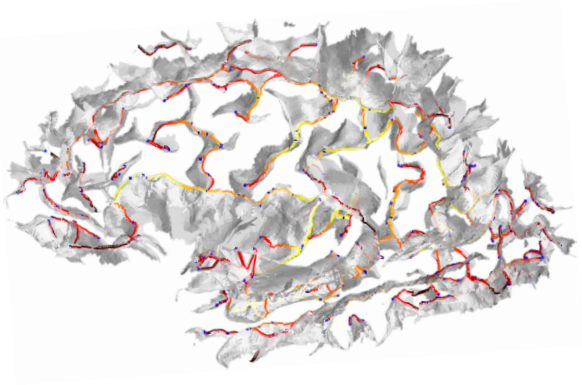
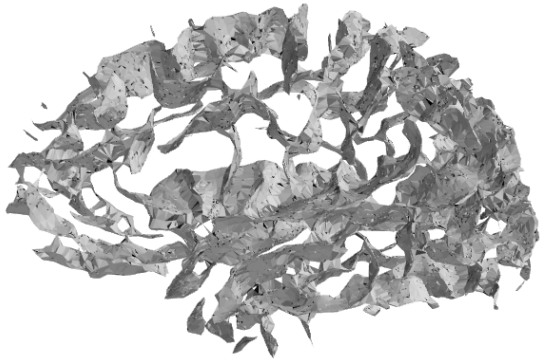
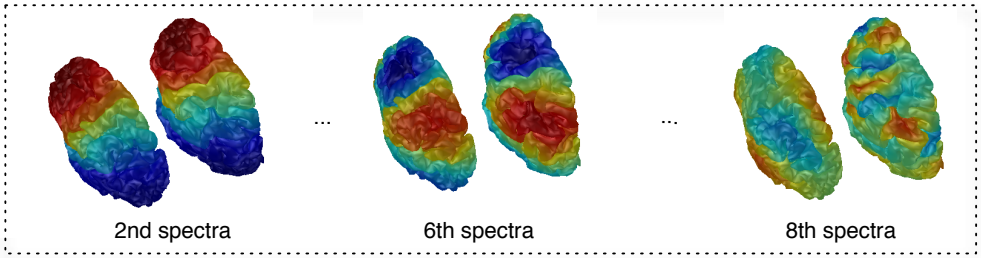
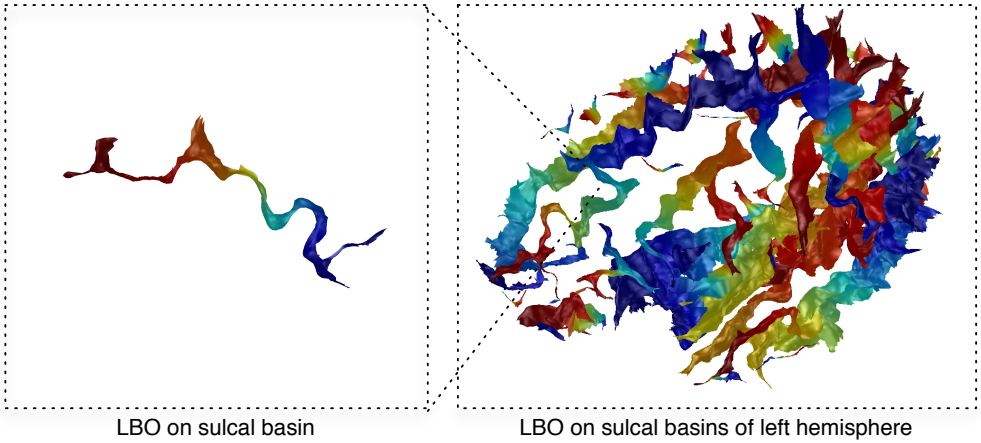






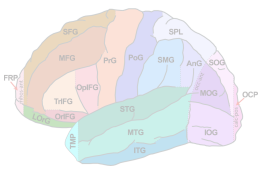
Global to local



LBO on sulcal basin

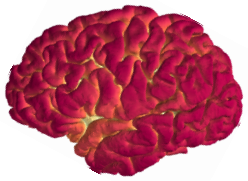
LBO on sulcal basins of left hemisphere

Morphometry of folds, fundi, medial surfaces, and labeled regions

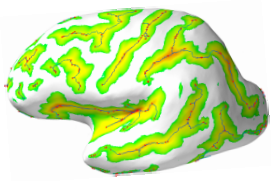


manual

Mindboggle



morphometry



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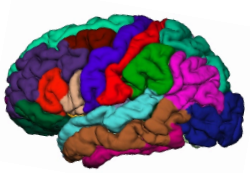
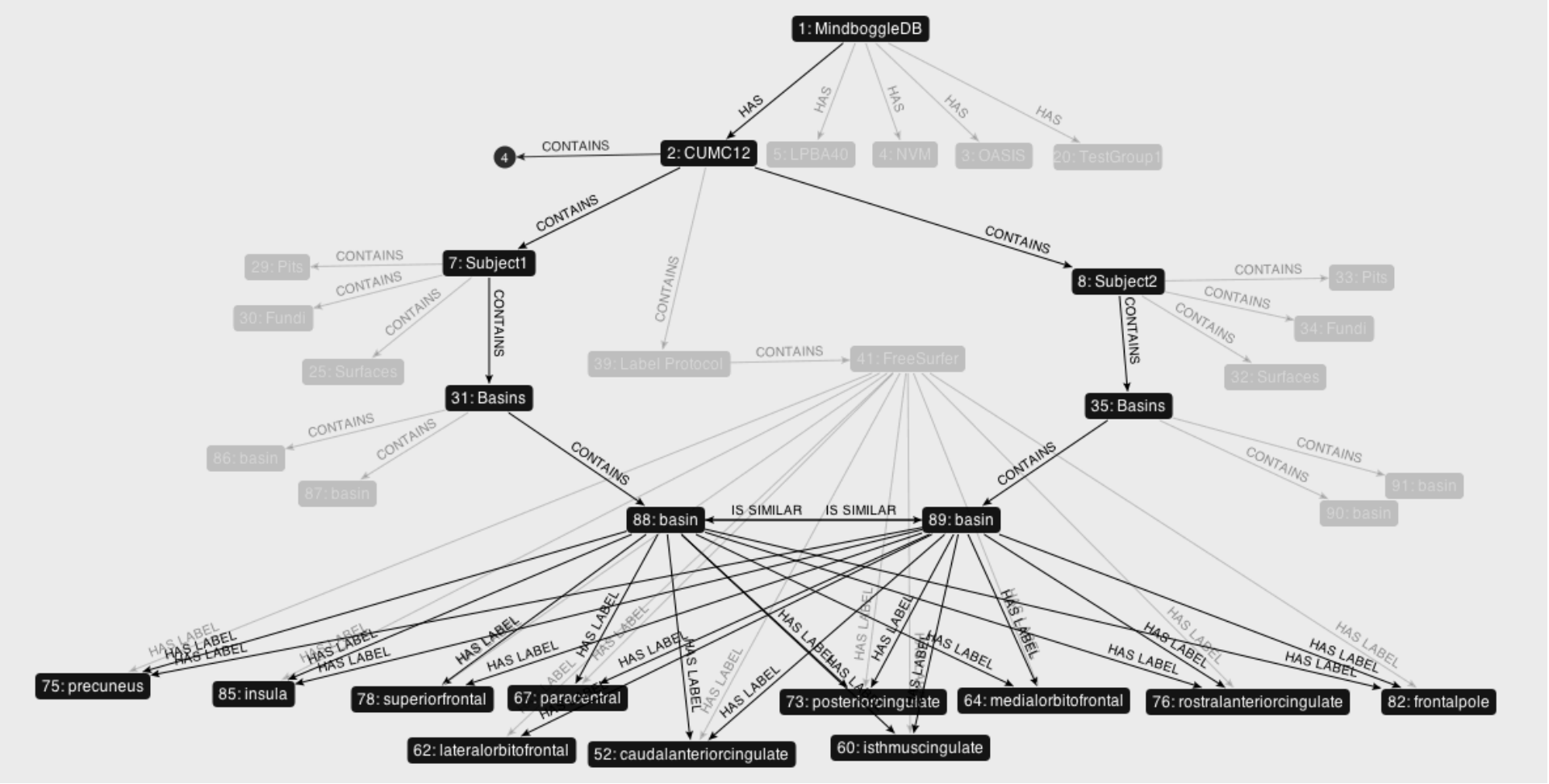
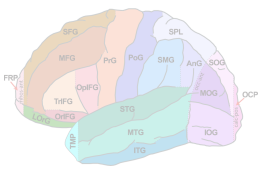


labels



Graph-based database of features and labels



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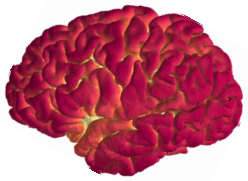
Mindboggle



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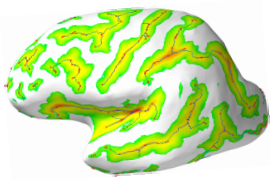

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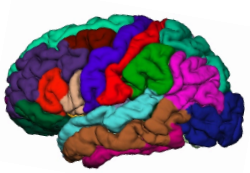

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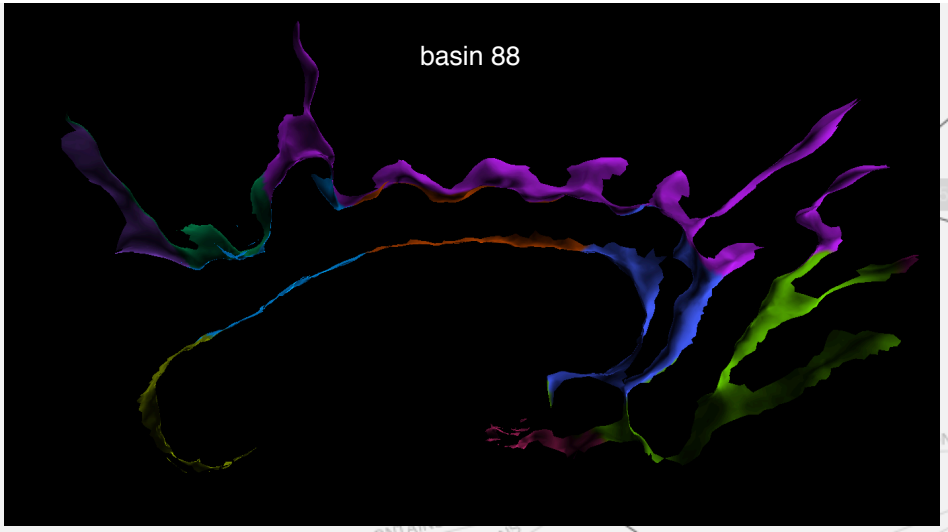
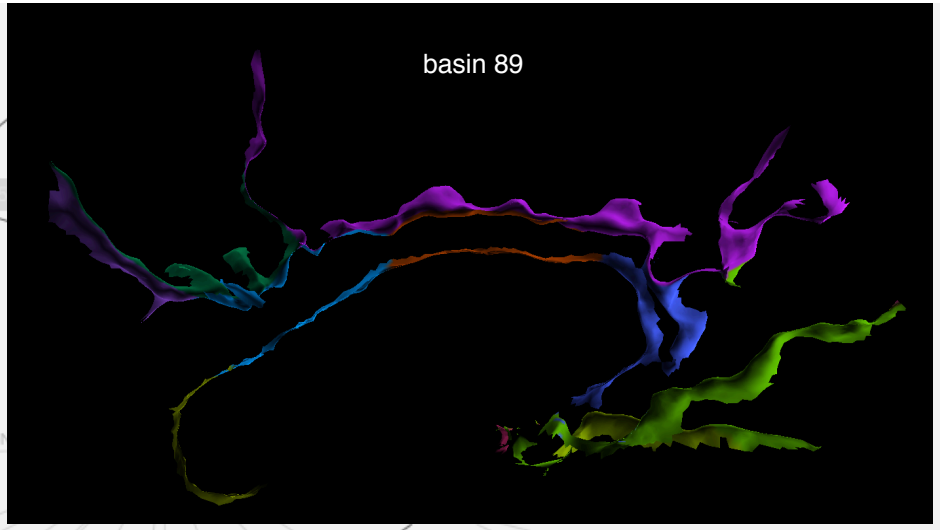
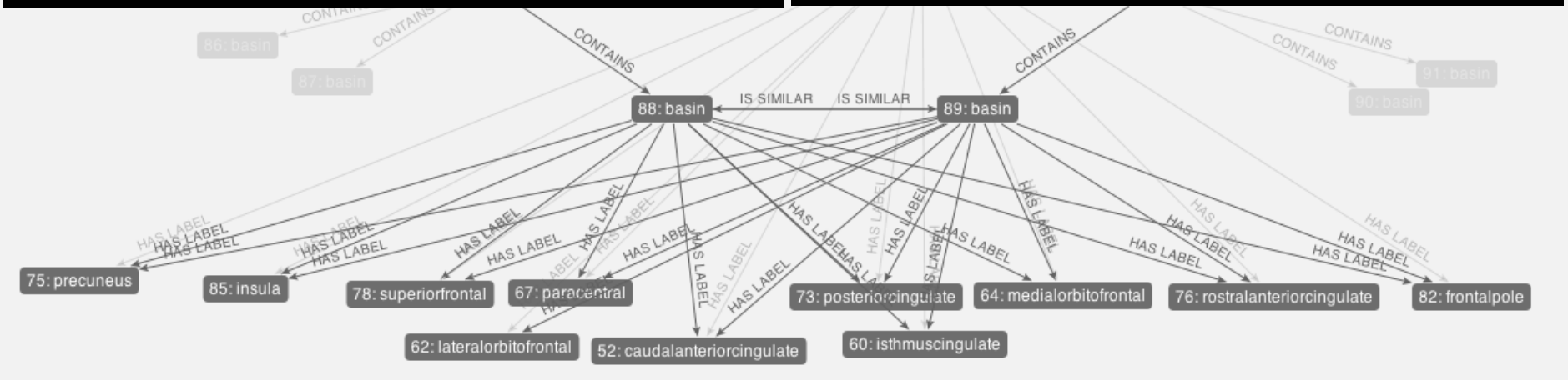
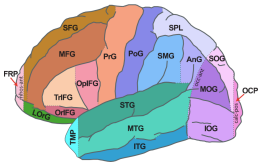






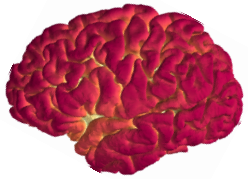
Example database query

Current Mindboggle

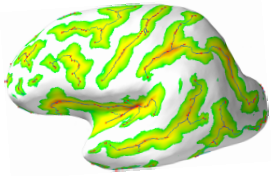


101 manually labeled brain atlases and shape database

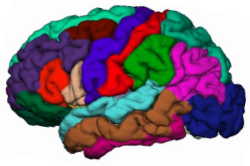
Mindboggle software:



- measures shapes



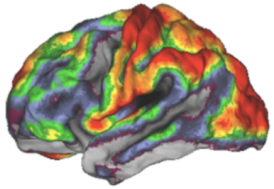
- identifies features



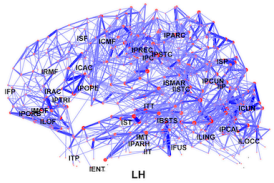
- labels regions

New Mindboggle 1-year grant

Mindboggle software will include:

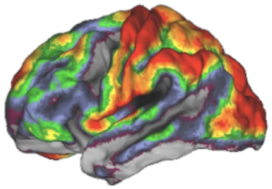


- fMRI features

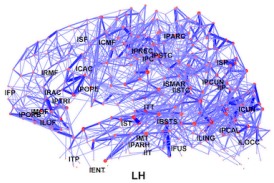


- dMRI features

Mindboggle

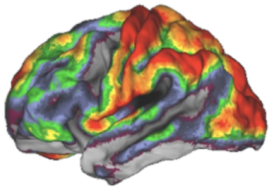


fMRI features



dMRI features

Mindboggle



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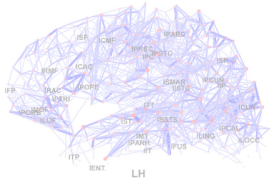
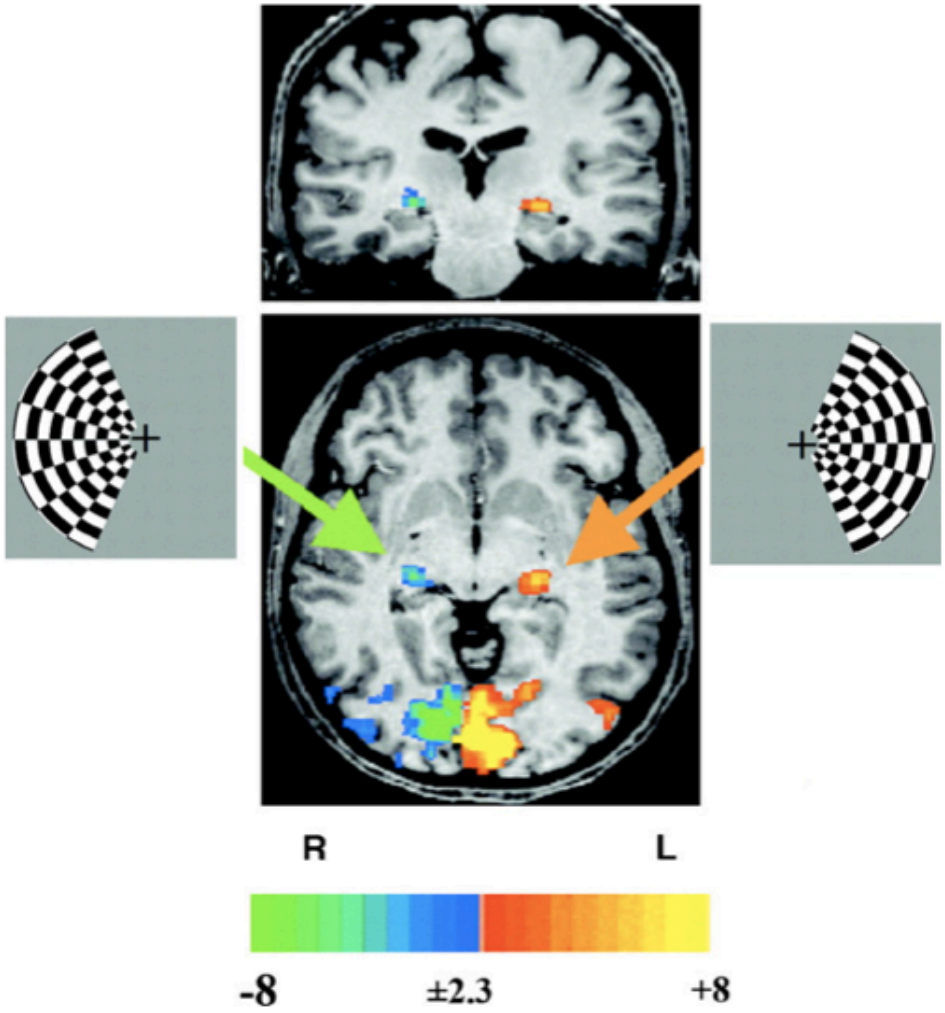
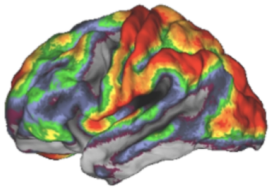


dMRI features



Kastner, et al., 2004

Mindboggle



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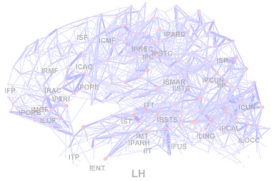

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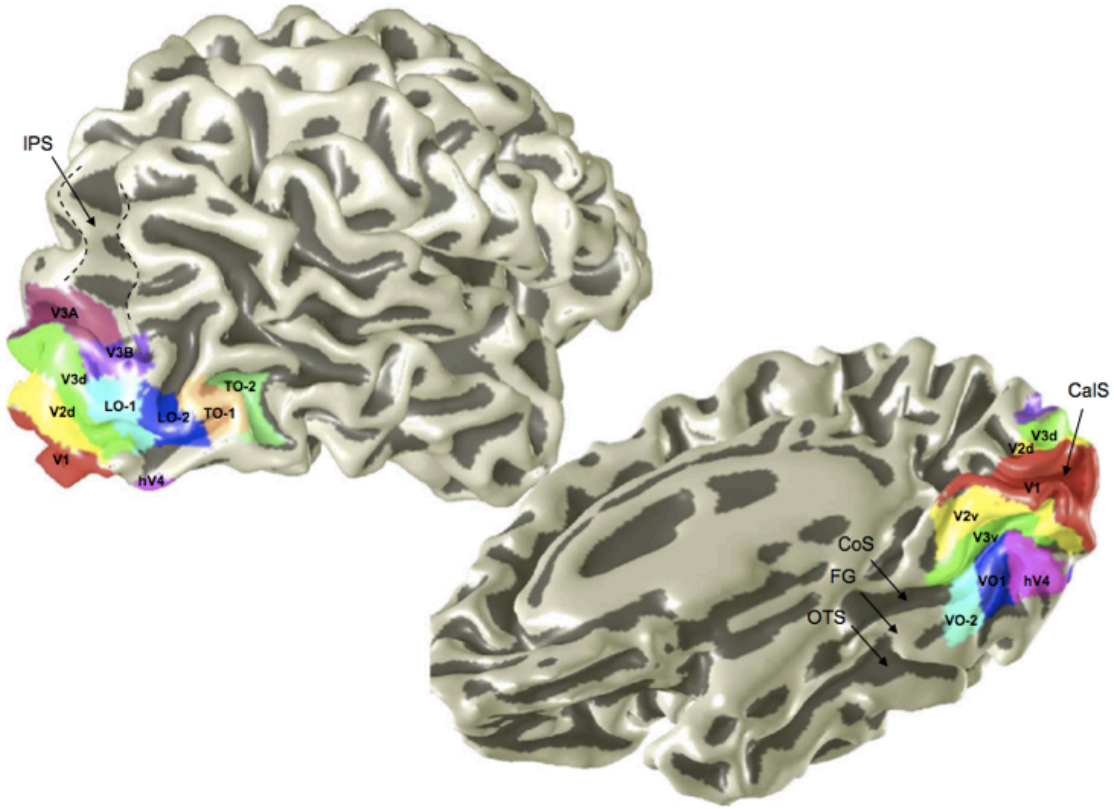

Visuotopic mapping

Wandell and Winawer, 2011

le.com - Calendar | Mindboggle labels and label | Mindboggle on the cloud - C | Mindboggle Roadmap - Goo | Yeo_etal_JNeurophysiol_201
TvKnFaA&feature=player_detailpage

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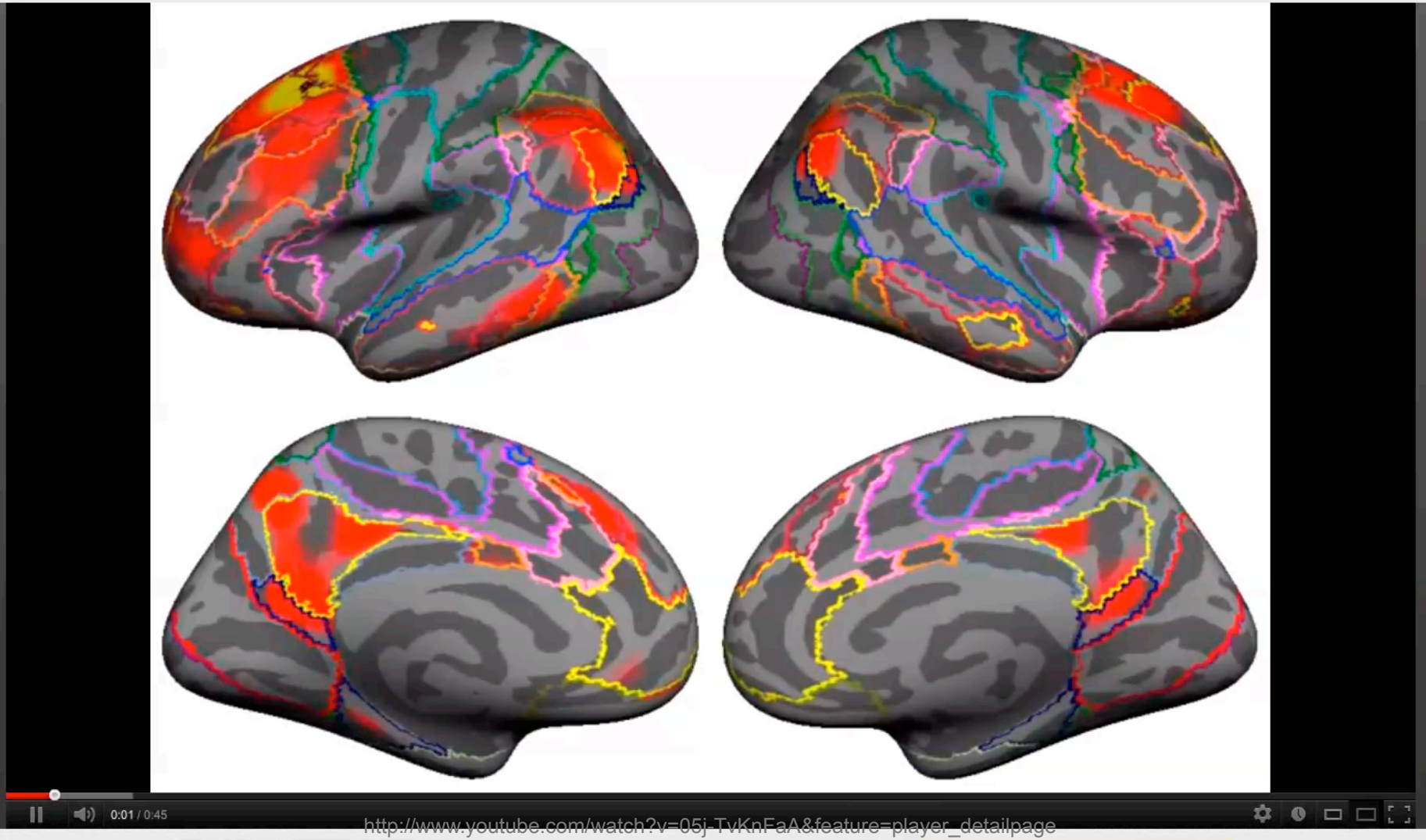

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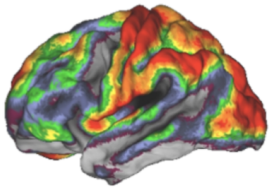

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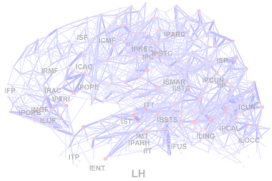

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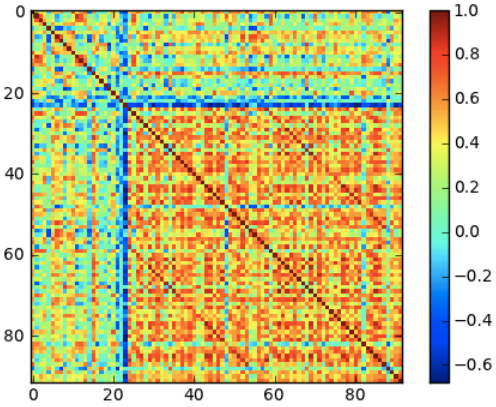
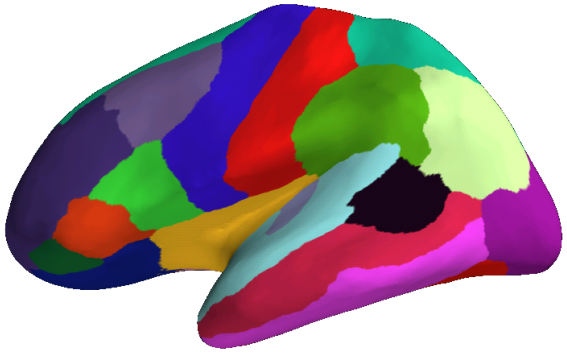
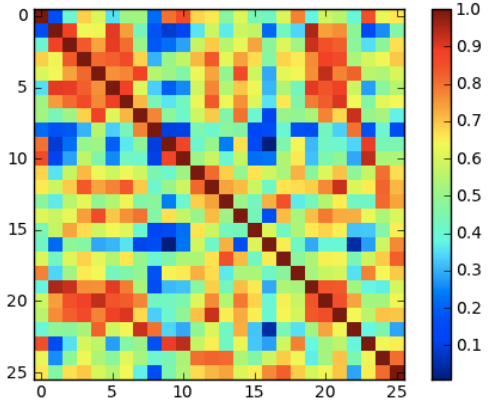
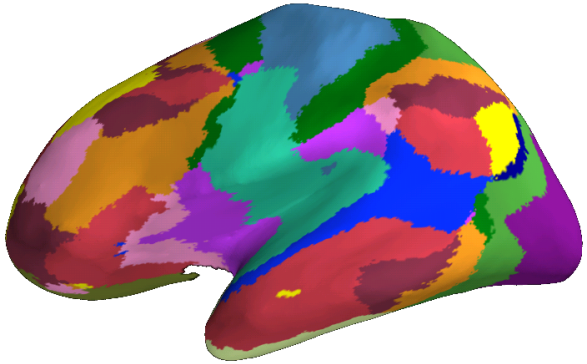


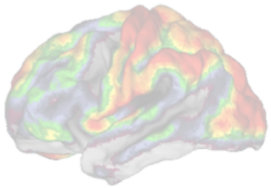






fMRI-connected features

Mindboggle



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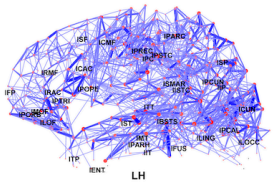

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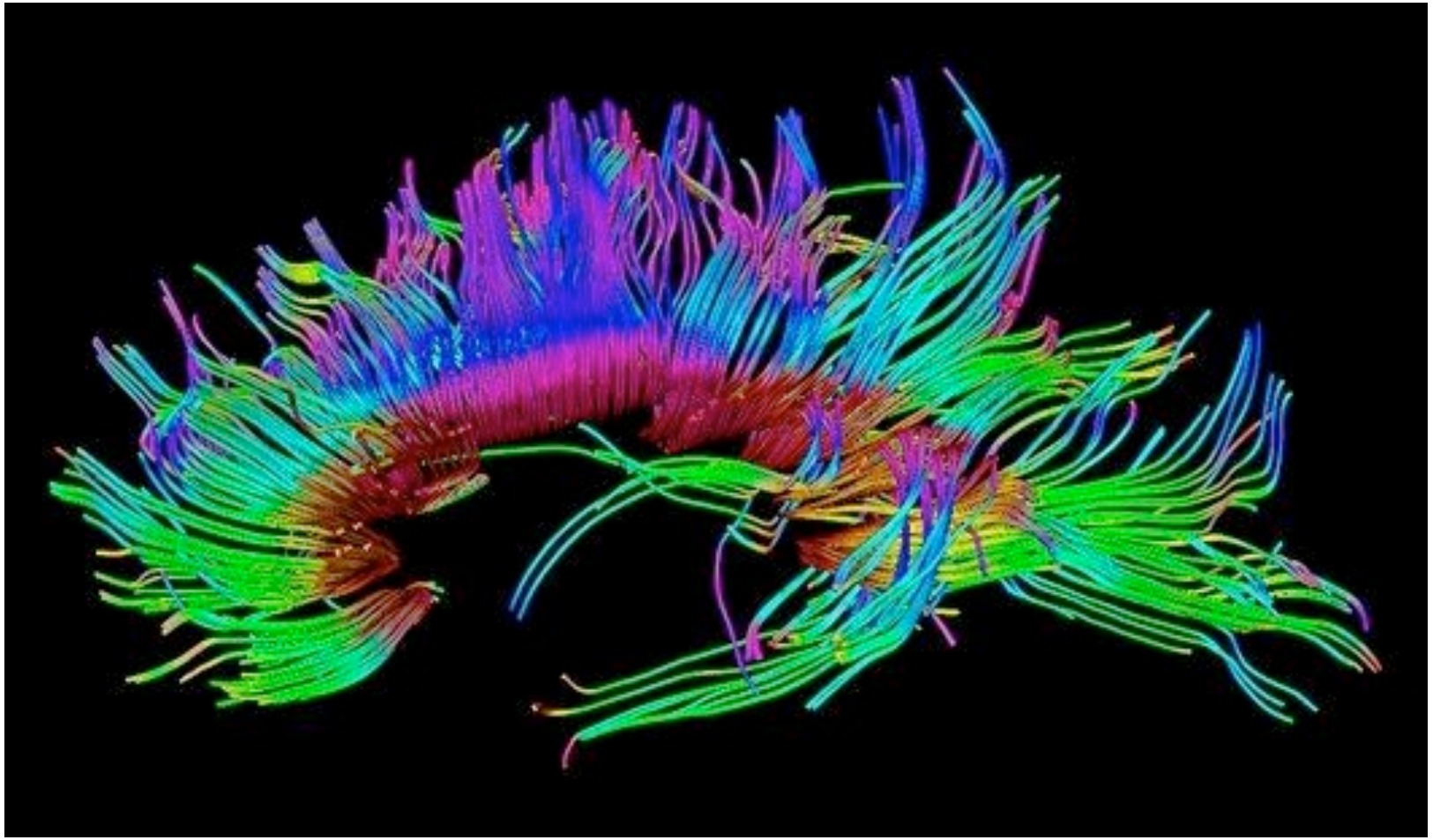
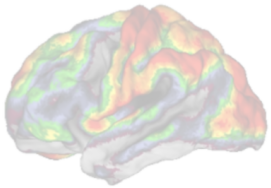


Diffusion tractography

Wiegall et al., 2003, Kirby

Mindboggle



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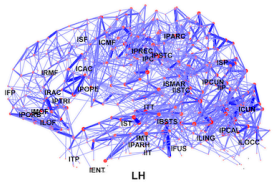
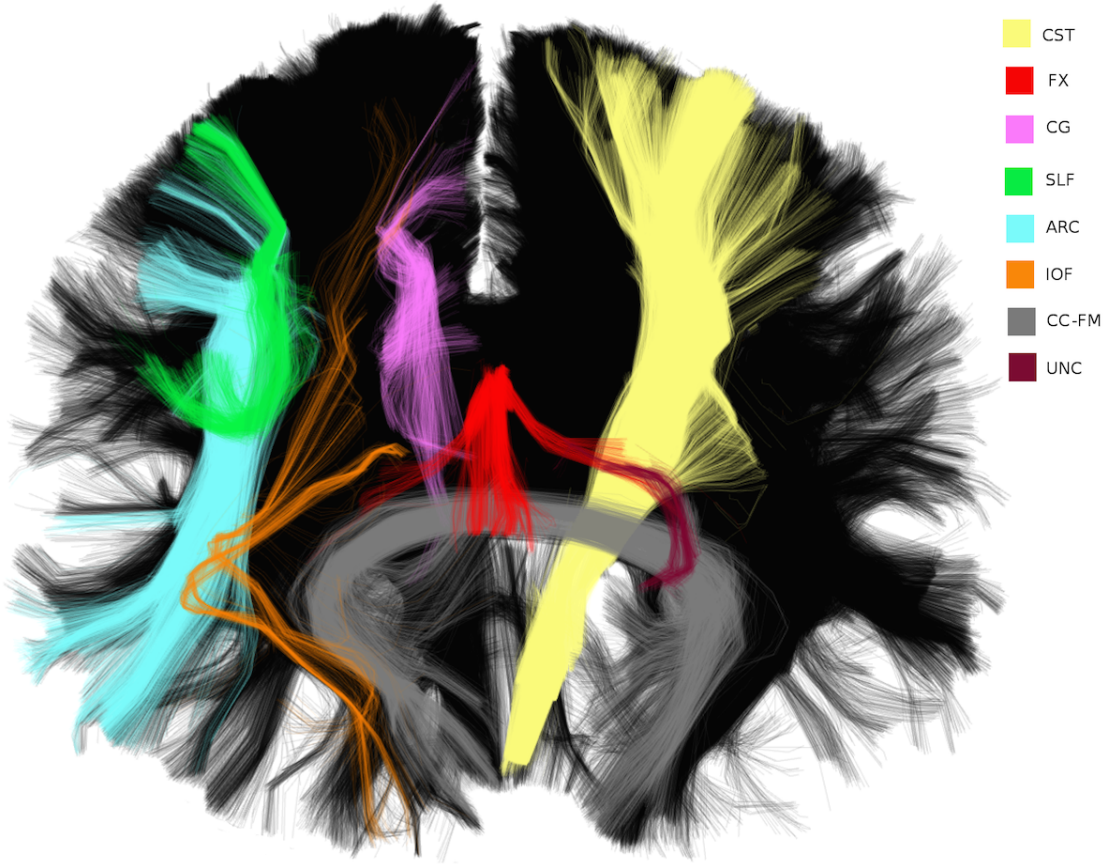


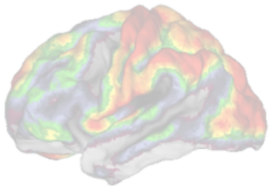
dMRI features



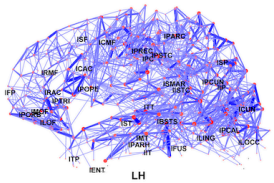
Tractography features

Eleftherios Garyfallidis, 2011

Mindboggle



fMRI features



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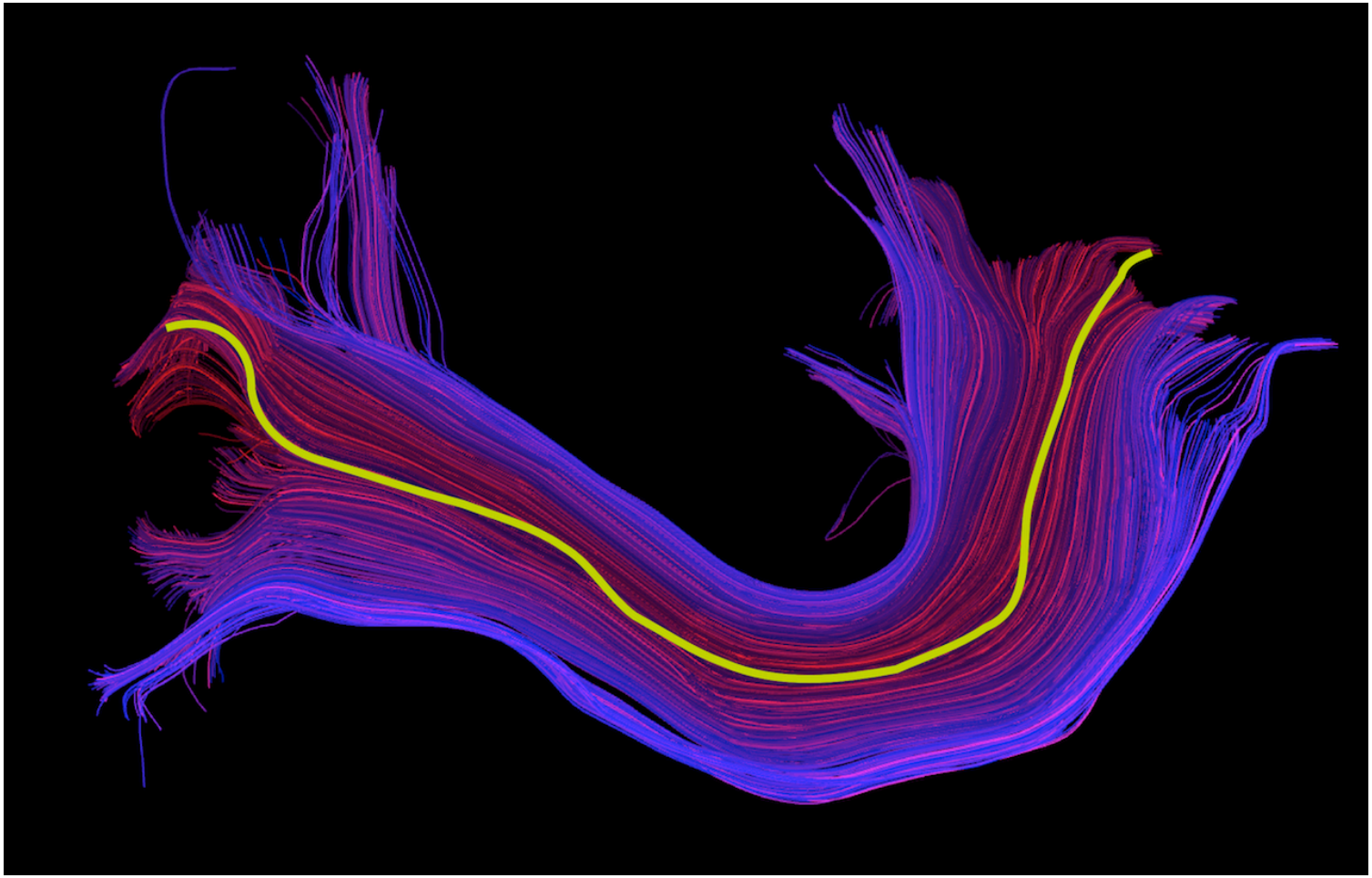

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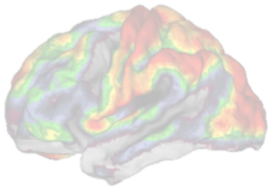

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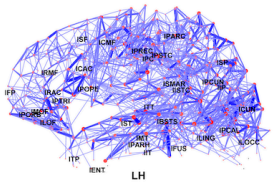

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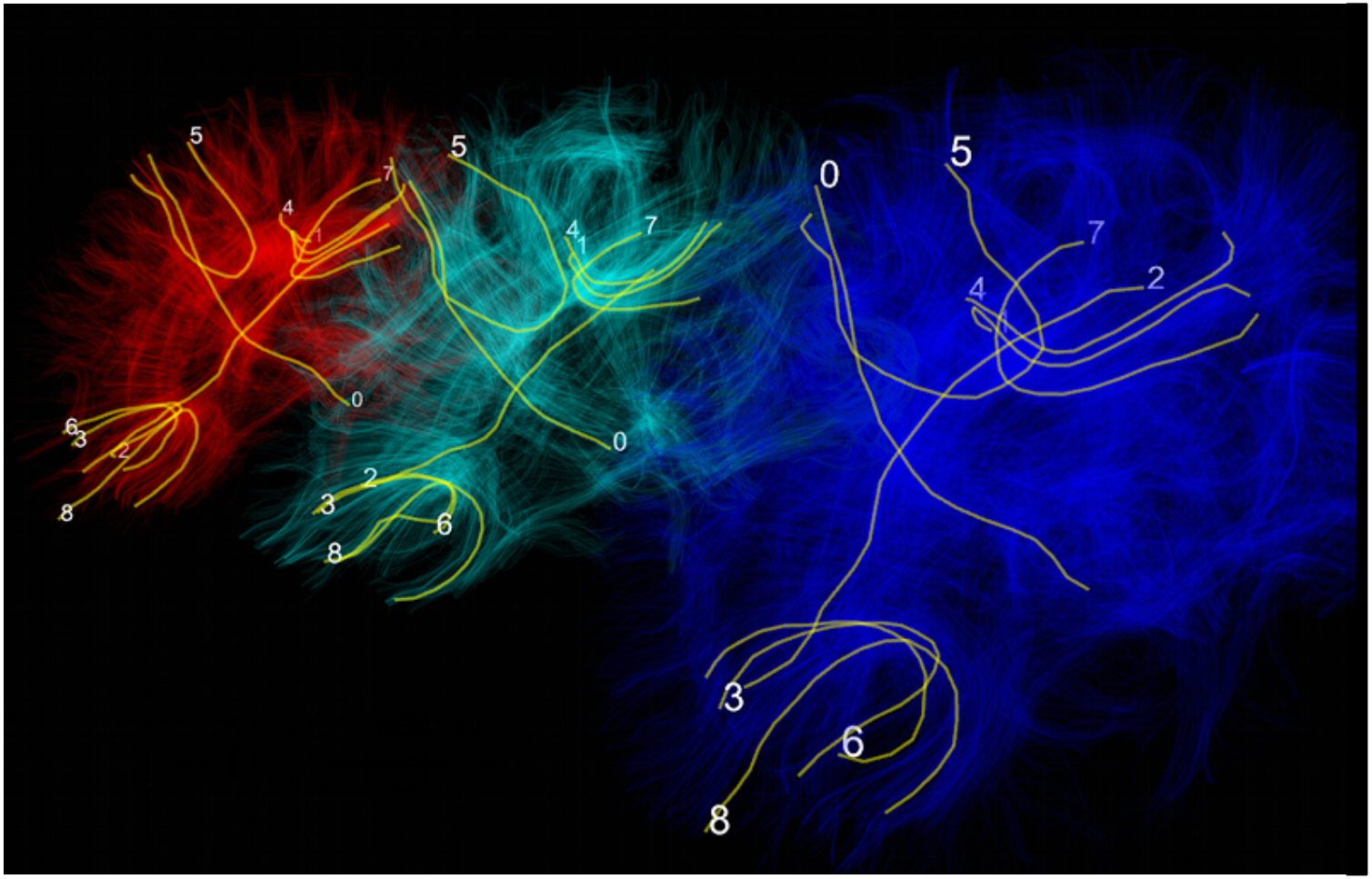

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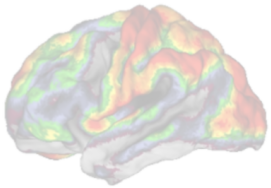

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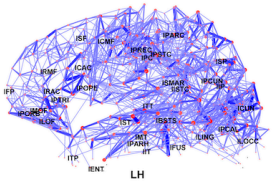

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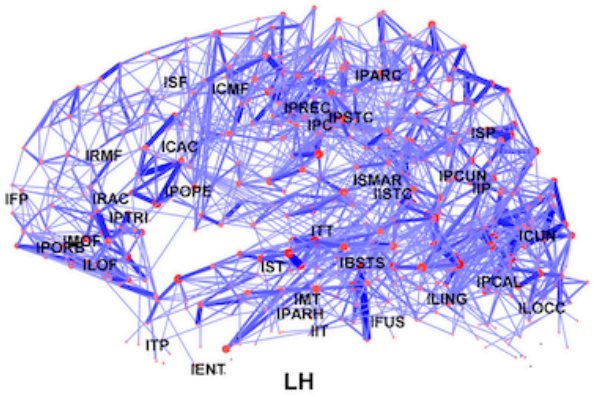
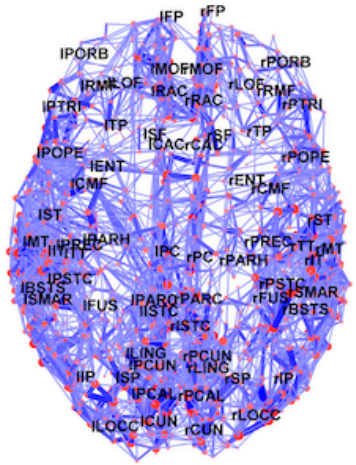
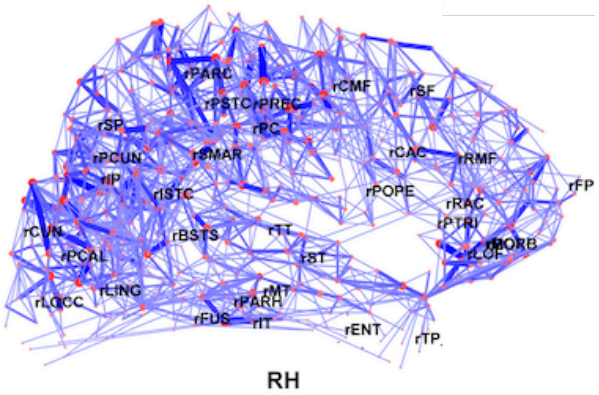
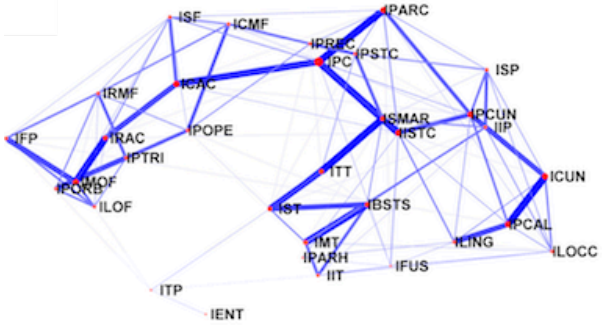
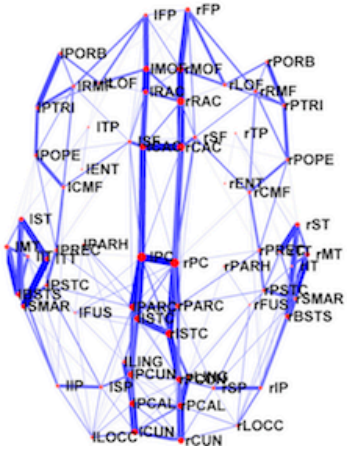
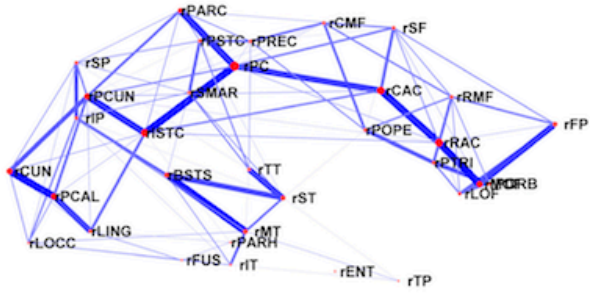








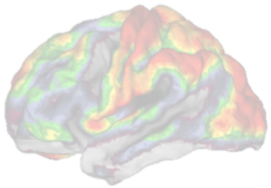




Tractography networks

Hagmann, et al., 2008

Mindboggle



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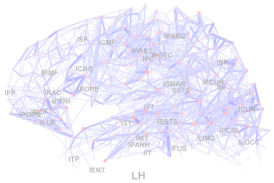
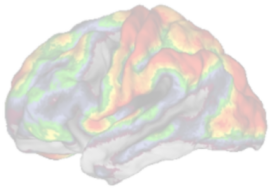


dMRI features

Mindboggle software:

- Python and Python-wrapped C++
- Open source, freely available
- Software pipeline framework
- Allow users to upload images to a server

Mindboggle



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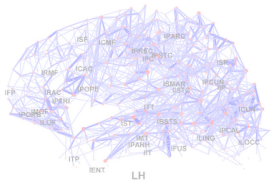

dMRI features

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The 128-core server system
is on its way to Stony Brook!

Mindboggle team

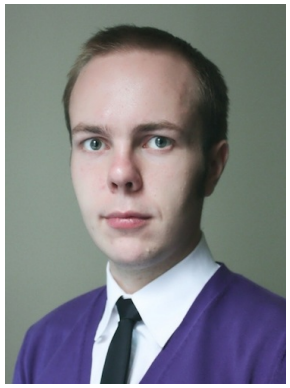
Depth and curvature

Joachim Giard
Univ. Catholique de Louvain, Belgium

Nested features

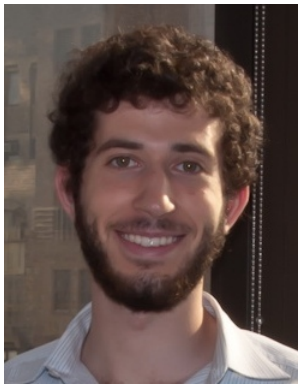
Forrest Bao
Texas Tech

Probabilistic features



Yrjö Häme
Columbia PhD student

Label propagation



Eliezer Stavsky
Columbia PhD student

Anatomical labeling

Greg Millington
Neuromorphometrics, Inc.

Jason Tourville
Boston U.

dMRI features

Eleftherios Garyfallidis
Cambridge University

Machine learning

Satrajit Ghosh
MIT