neurodata.io

m2g: an MRI Processing Reference Pipeline for Connectome Estimation

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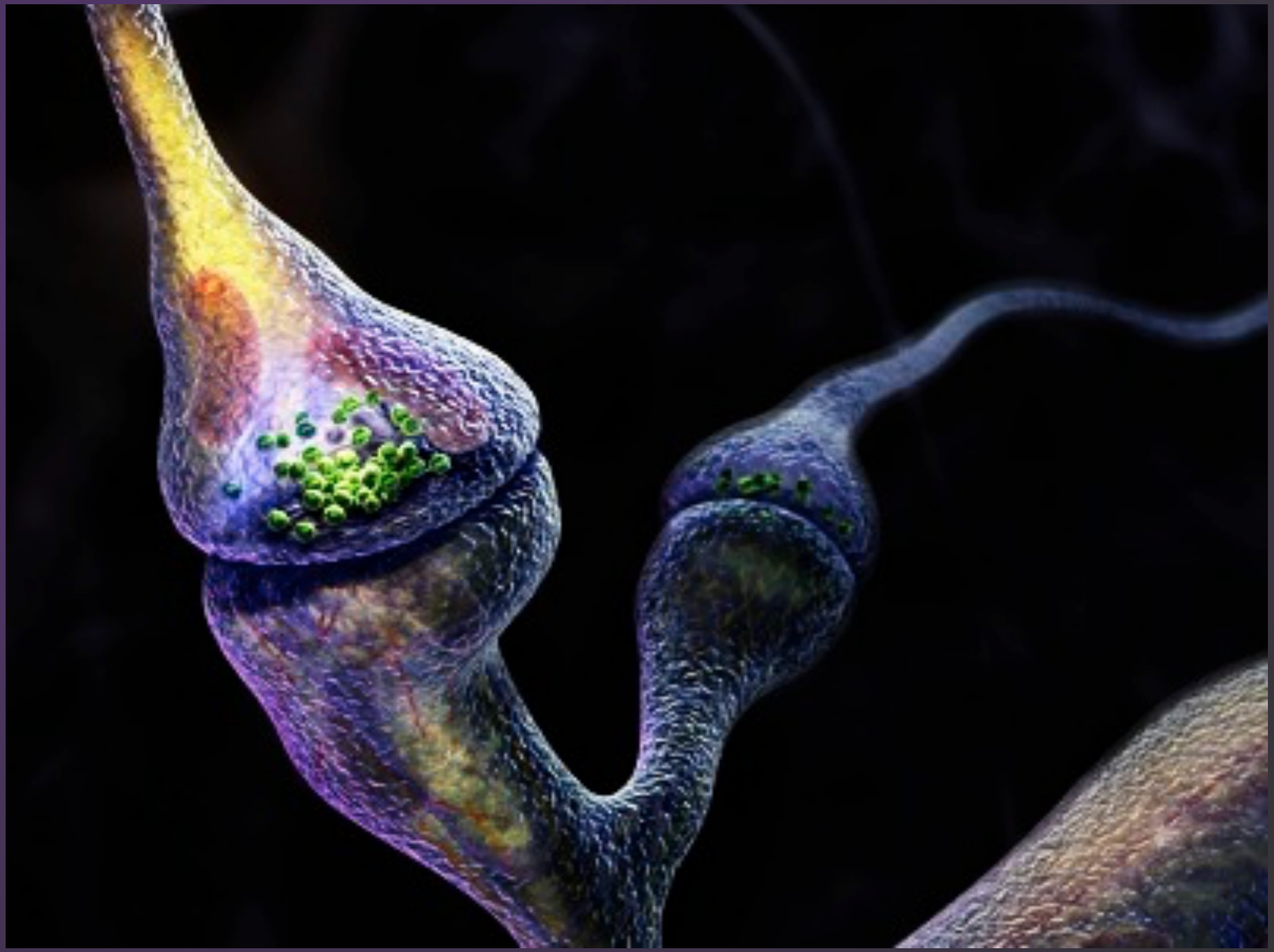
Overview

- Mission
- Methods
- Results
- Future



Datasets

- an abundance of MR data
- data collected with widely varying scanner parameters
- few unified scanner protocols

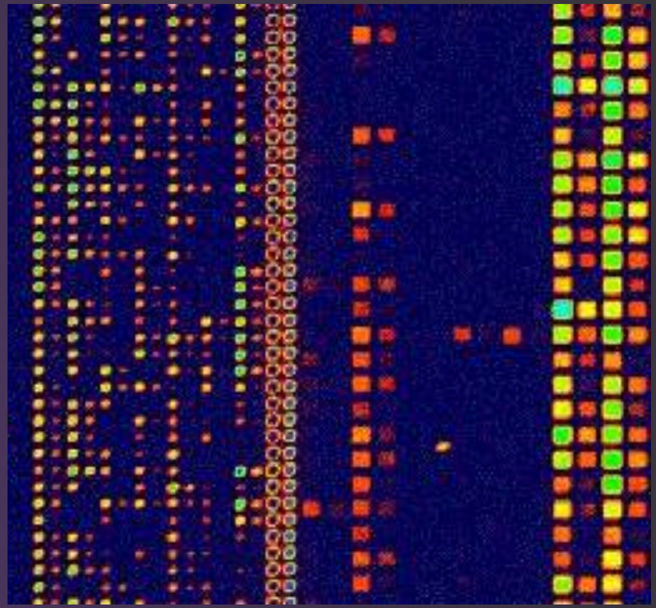
Dataset	Number of Subjects
CoRR	1386
HCP	542
OASIS	416
MRN-1313	1313
MRN-114	111
KKI-42	21
CASL-36	12
NKI/RS	207
...	...
Total	**4,044 +**

Processing tools

- a plethora of single-purpose tools exist
- a lack of end-to-end computational tools
- high computational barrier to entry

Mission

- Quantitative analysis of brain structure to predict or assess cognitive capabilities, medical diagnosis
- Lower the barrier for entry to large scale MR processing

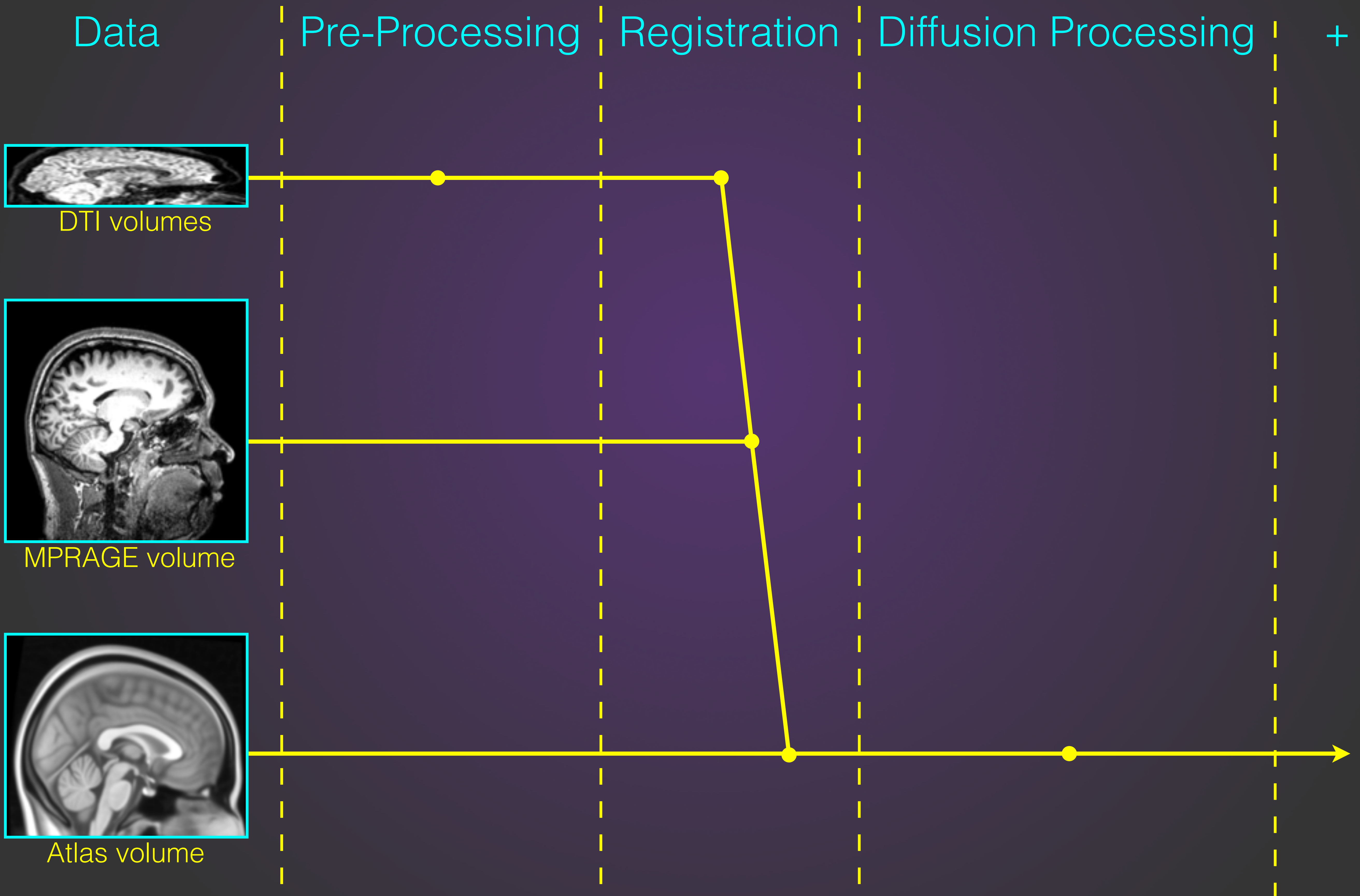



Connectomics is to the brain what Genomics is to DNA

What is m2g?

- Reference pipeline for diffusion and structural MRI processing
- Reliable connectome estimation at scale
- Platform for inference

m2g reference pipeline

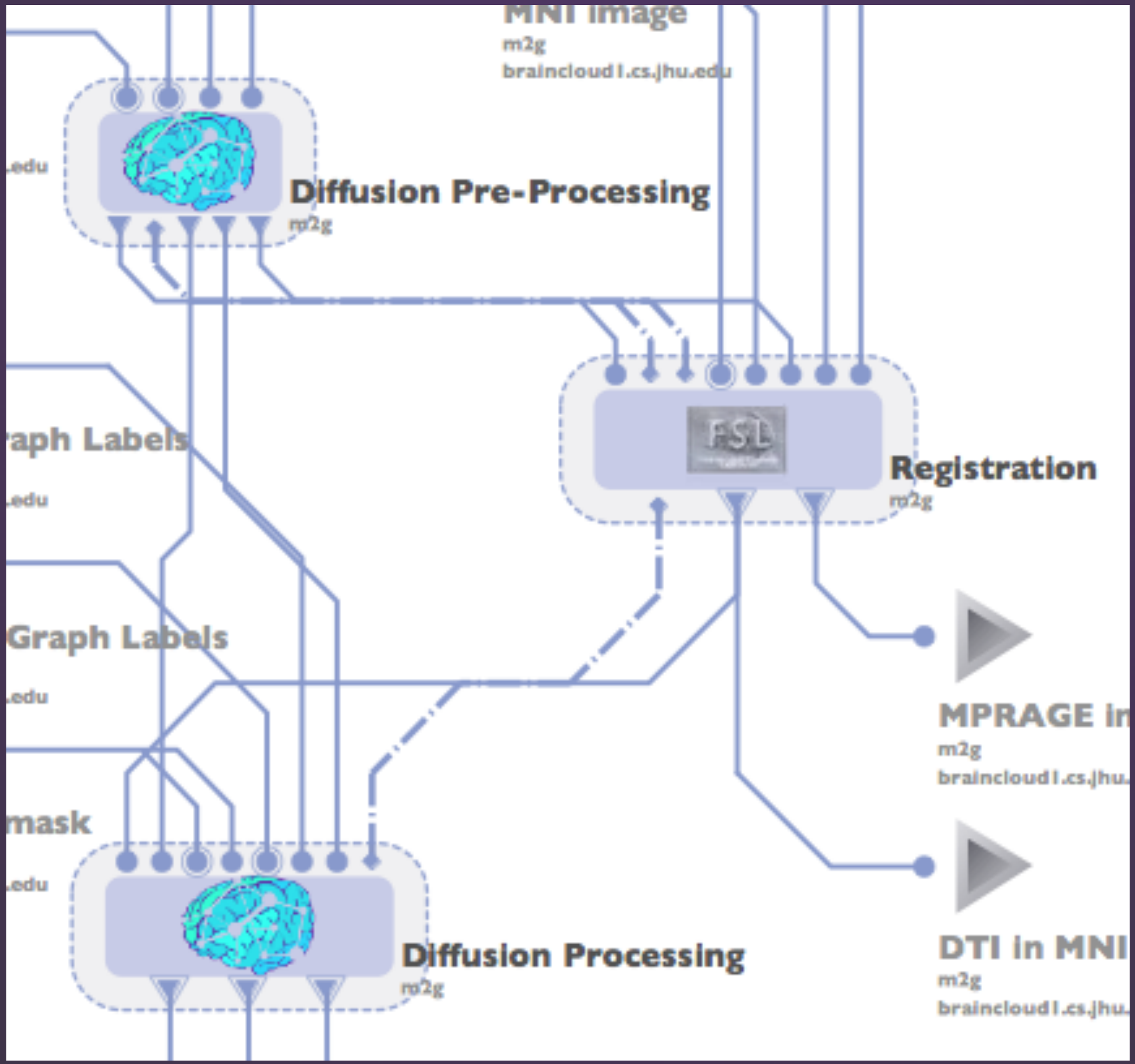


LONI Pipeline

- Framework for distributed computing
- Enables scalable implementation of processing workflows
- http://pipeline.loni.usc.edu

m2g implementation

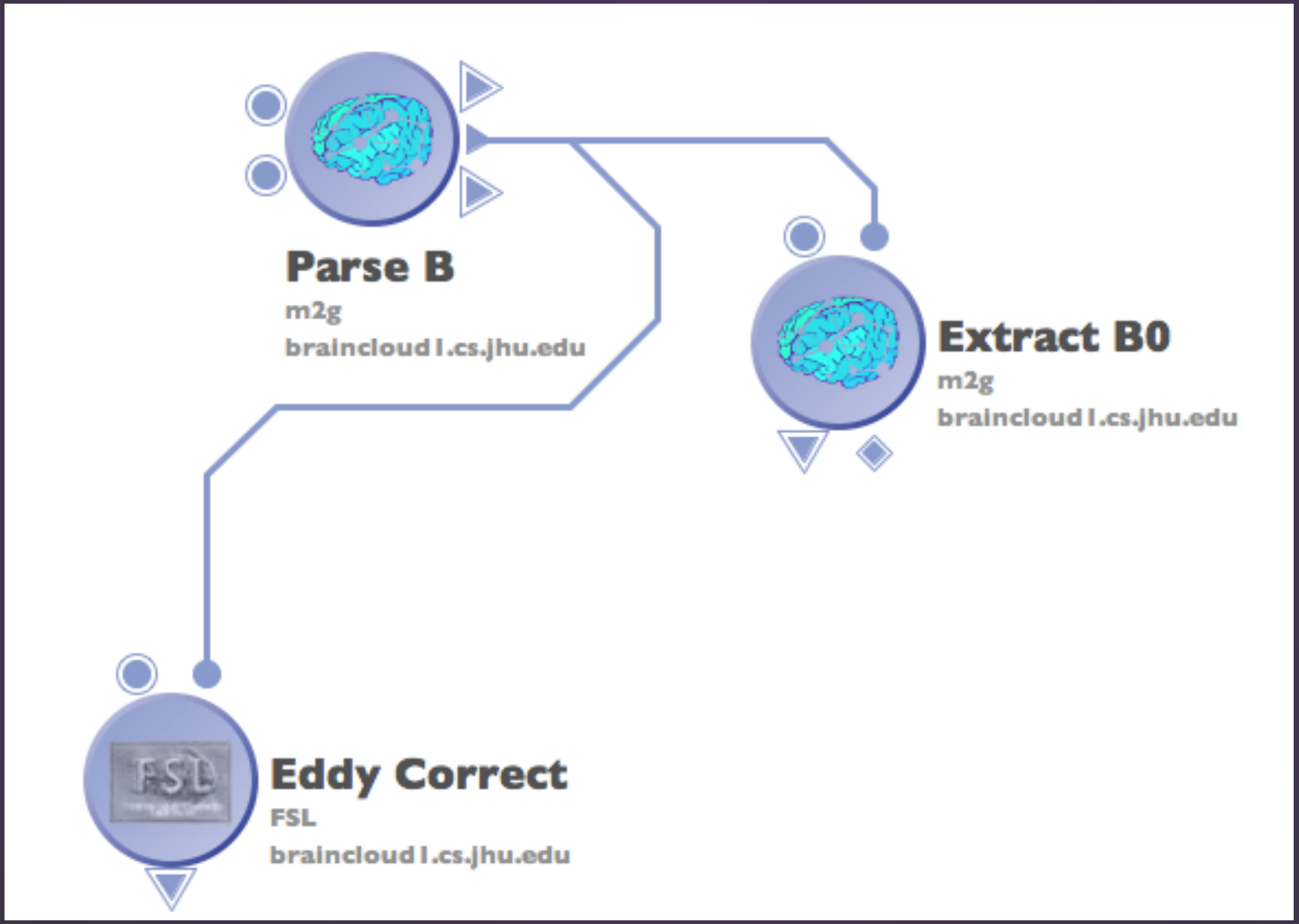
github.com/openconnectome/m2g



Sub-pipelines

- **Diffusion Pre-Processing** prepares the diffusion scan and parameters for advanced processing
- **Registration** maps the subject image data to the space defined by the template atlas
- **Diffusion Processing** exploits the diffusion data in order to estimate connectomes

diffusion pre-processing



Parse B

$$\begin{bmatrix} B_{x1} & B_{y1} & B_{z1} \\ B_{x2} & B_{y2} & B_{z2} \\ \vdots & \vdots & \vdots \\ B_{xd} & B_{yd} & B_{zd} \end{bmatrix}$$

B-vectors

$$\begin{bmatrix} B_1 & B_2 & \dots & B_d \end{bmatrix}$$

B-values

$$\longrightarrow$$

$$\begin{bmatrix} B_{x1} & B_{x2} & \dots & B_{xd} \\ B_{y1} & B_{y2} & \dots & B_{yd} \\ B_{z1} & B_{z2} & \dots & B_{zd} \end{bmatrix}$$

Formatted B-vectors

$$\begin{bmatrix} B_1 & B_2 & \dots & B_d \end{bmatrix}^T$$

Formatted B-values

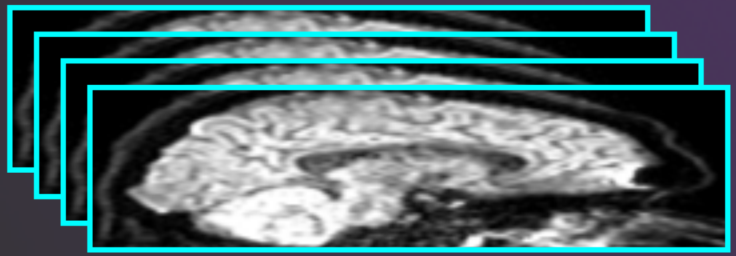
$$ind(B_i == 0)$$

Location of B0

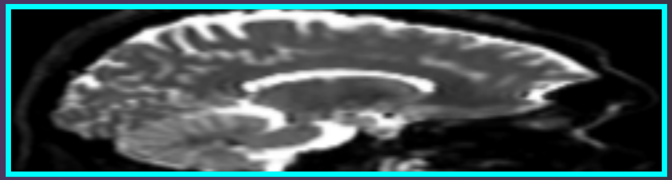
Extract B0

$ind(B_i == 0)$

Location of B0 volume



DTI volumes

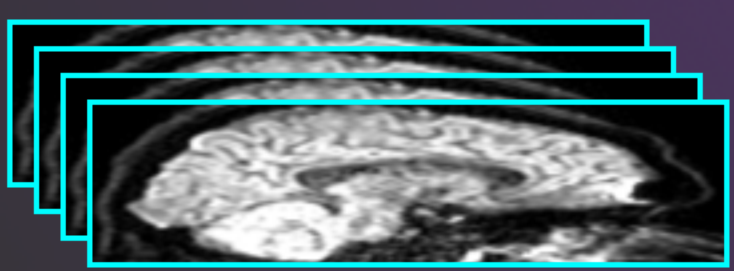


B0 volume

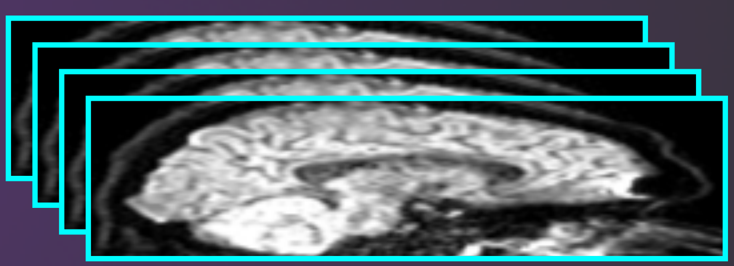
Eddy Correction

$$ind(B_i == 0)$$

Location of B0 volume

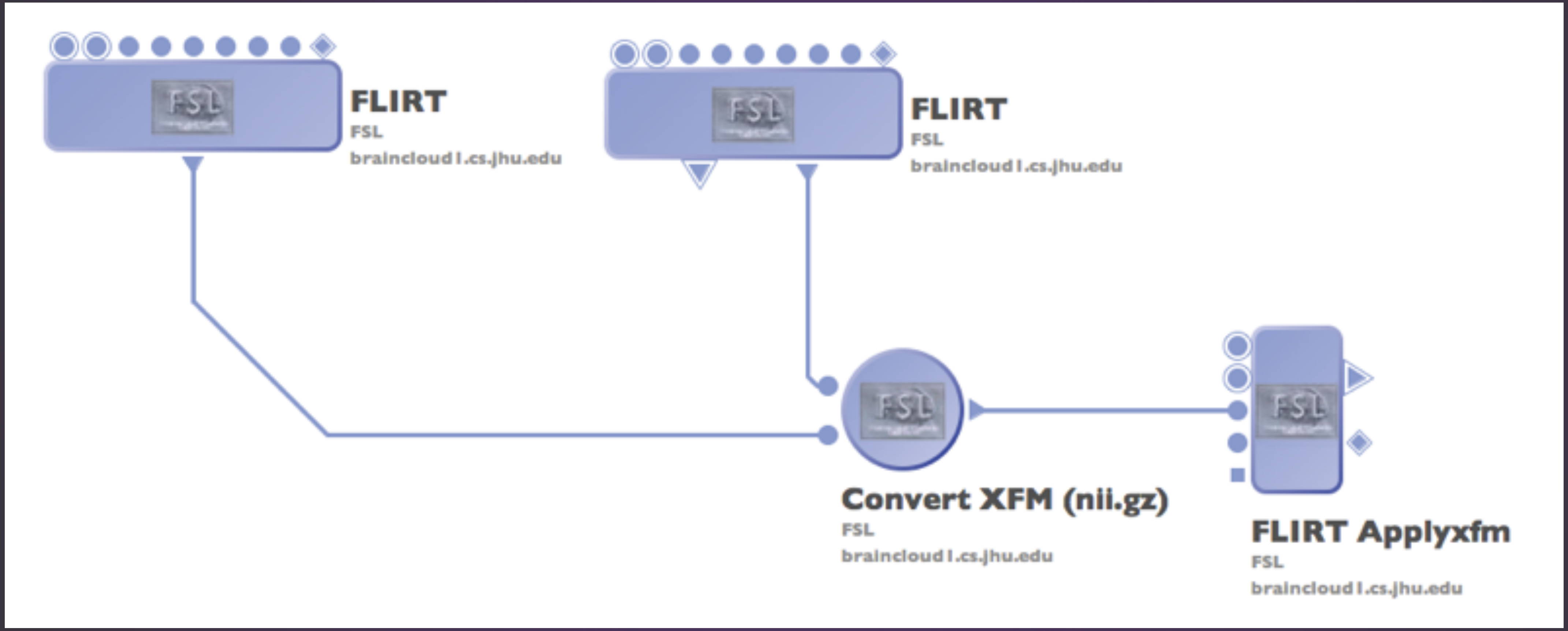


DTI volumes

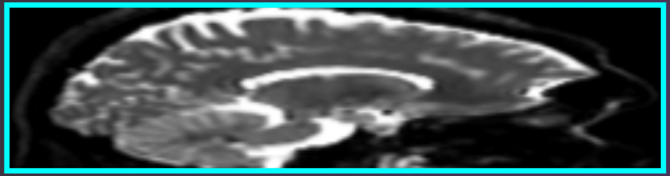


Eddy-corrected DTI volumes

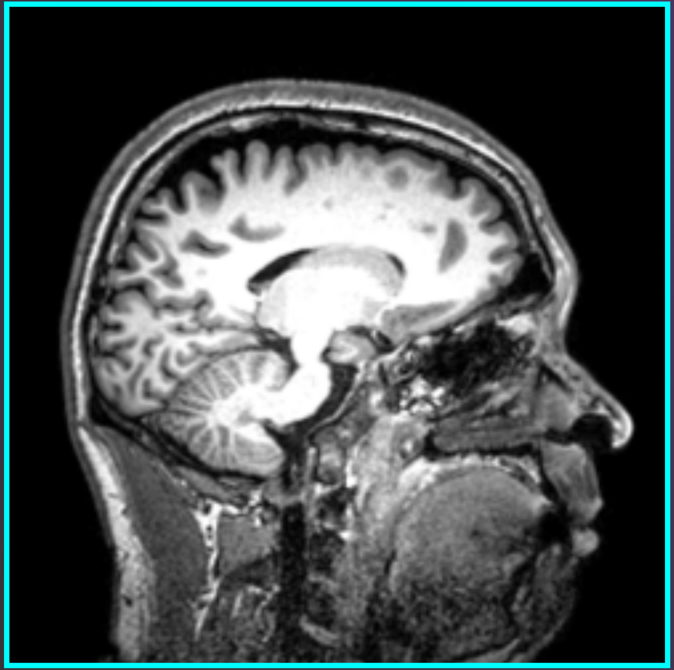
registration



FLIRT (1)



B0 volume

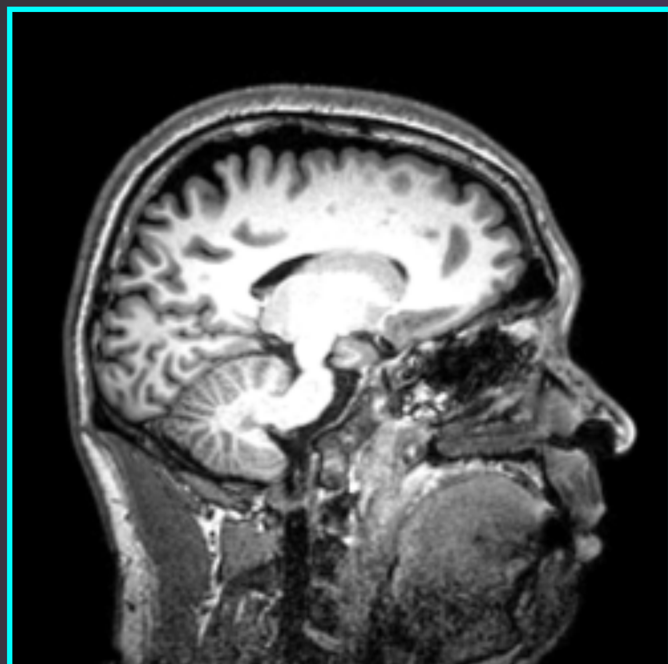


MPRAGE volume

$$A = \begin{bmatrix} a_{1,1} & & \\ & \ddots & \\ & & a_{4,4} \end{bmatrix}$$

Transform 1

FLIRT (2)



MPRAGE volume

Atlas volume

$$A = \begin{bmatrix} a_{1,1} & & \\ & \ddots & \\ & & a_{4,4} \end{bmatrix}$$

Transform 2

Convert Transforms

$$A = \begin{bmatrix} a_{1,1} & & \\ & \ddots & \\ & & a_{4,4} \end{bmatrix}$$

Transform 1

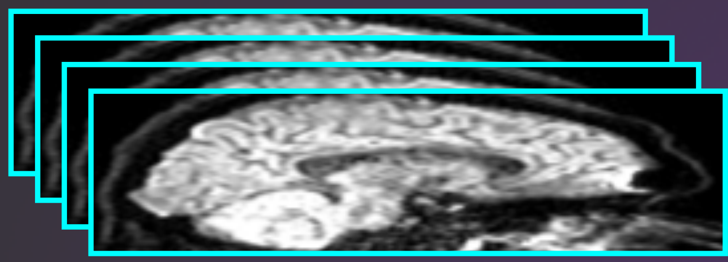
$$B = \begin{bmatrix} b_{1,1} & & \\ & \ddots & \\ & & b_{4,4} \end{bmatrix}$$

Transform 2

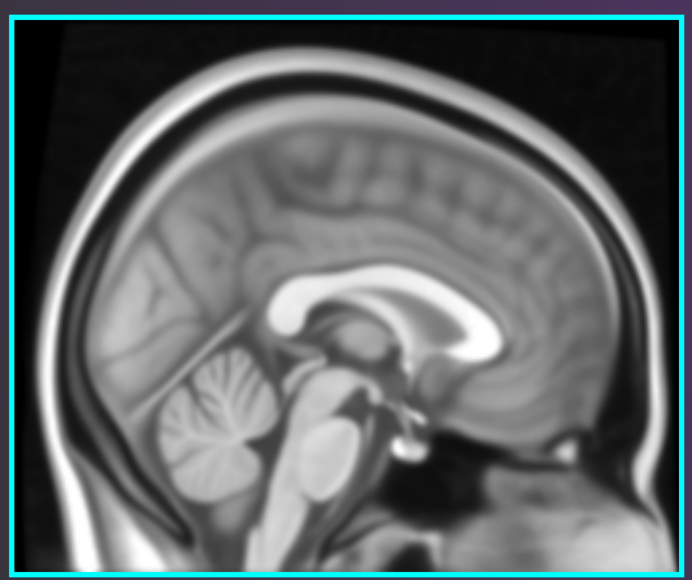
$$\longrightarrow \quad C = A \circ B = \begin{bmatrix} c_{1,1} & & \\ & \ddots & \\ & & c_{4,4} \end{bmatrix}$$

Combined Transform

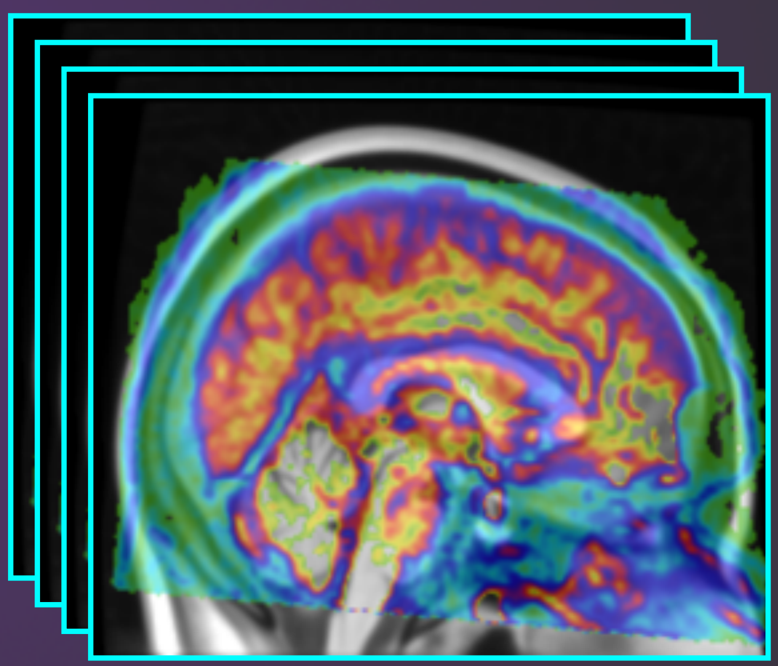
Apply Transforms



Eddy-corrected
DTI volumes



Atlas volume

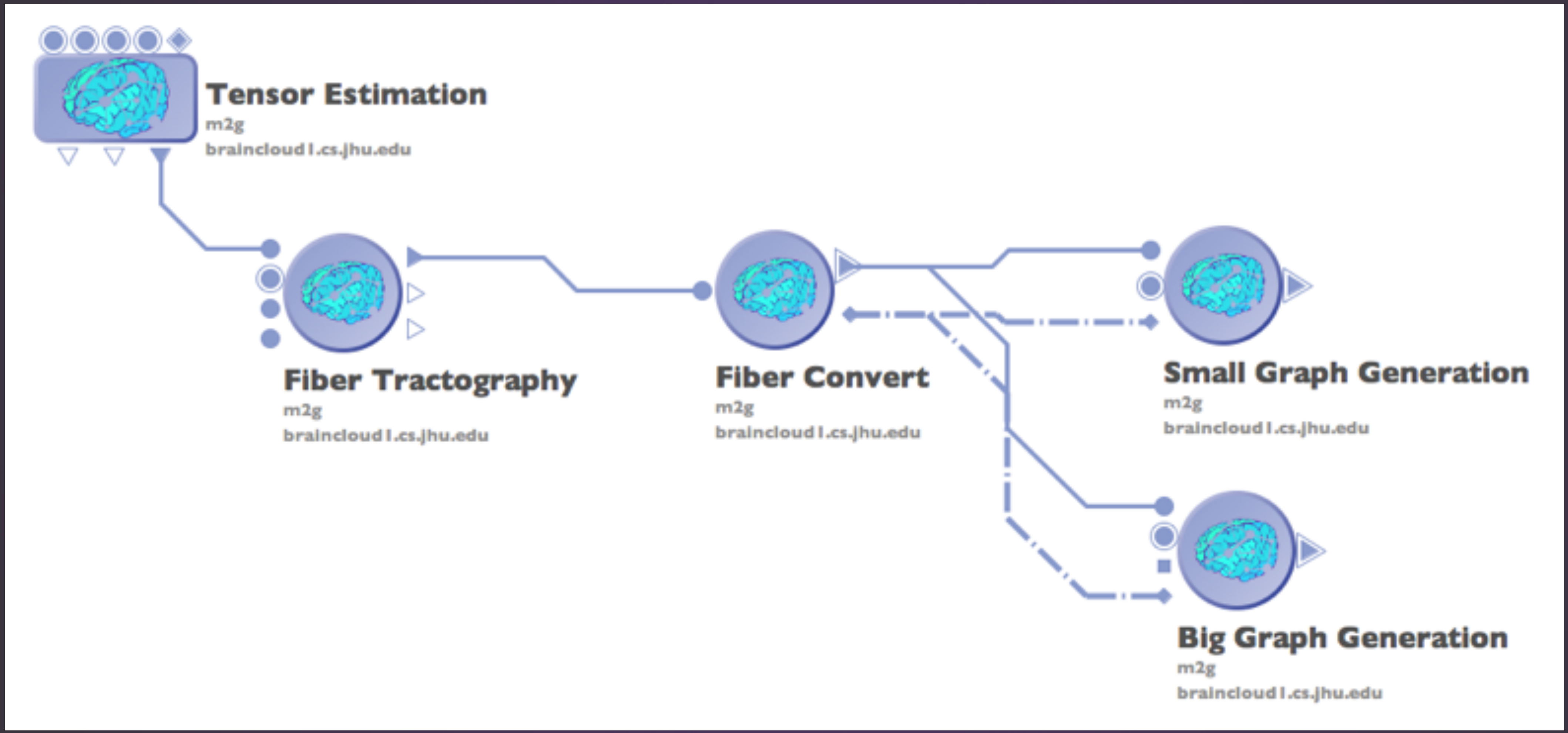


Aligned DTI volumes

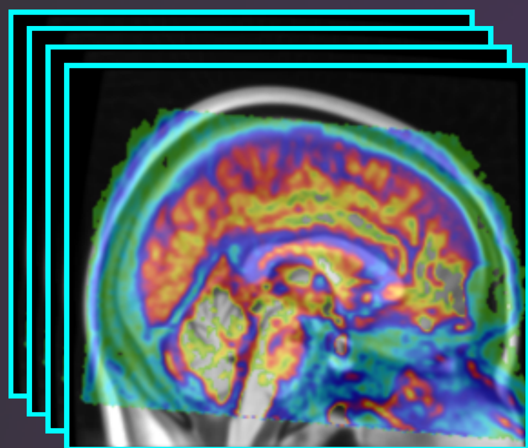
$$C = A \circ B = \begin{bmatrix} c_{1,1} & & \\ & \ddots & \\ & & c_{4,4} \end{bmatrix}$$

Combined Transform

diffusion processing



ODF Estimation

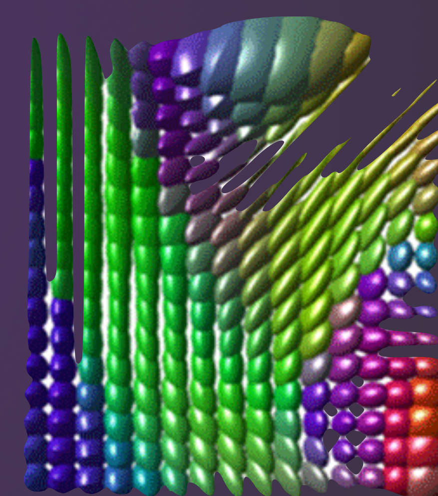


Aligned DTI volumes

Brain mask

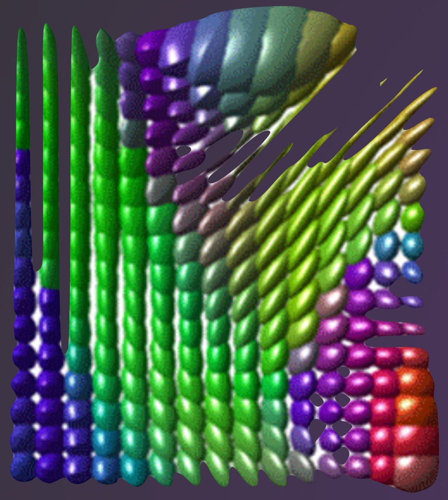
$$\begin{bmatrix} B_{x1} & B_{x2} & \dots & B_{xd} \\ B_{y1} & B_{y2} & \dots & B_{yd} \\ B_{z1} & B_{z2} & \dots & B_{zd} \end{bmatrix}$$

Formatted B-vectors



Diffusion tensors/ODFs

Fiber Tractography

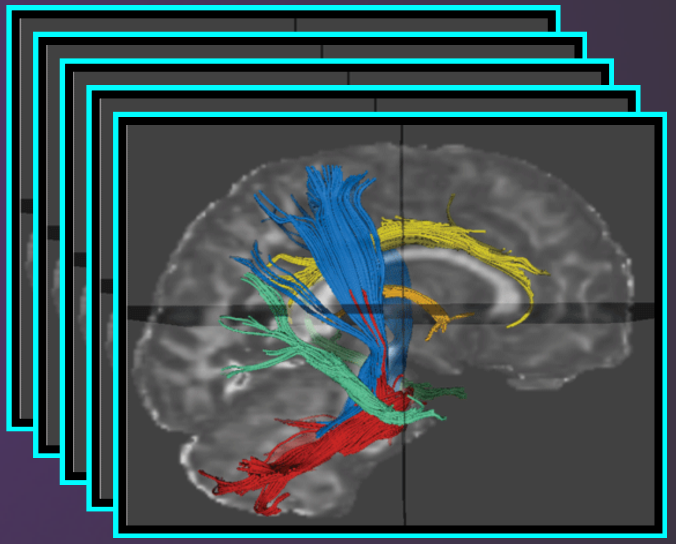


Diffusion tensors/ODFs

Brain mask

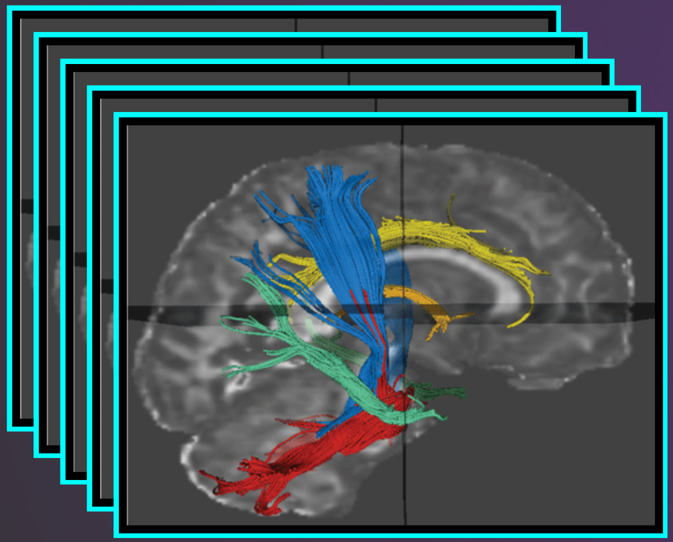
b_{fa}

Fractional anisotropy threshold

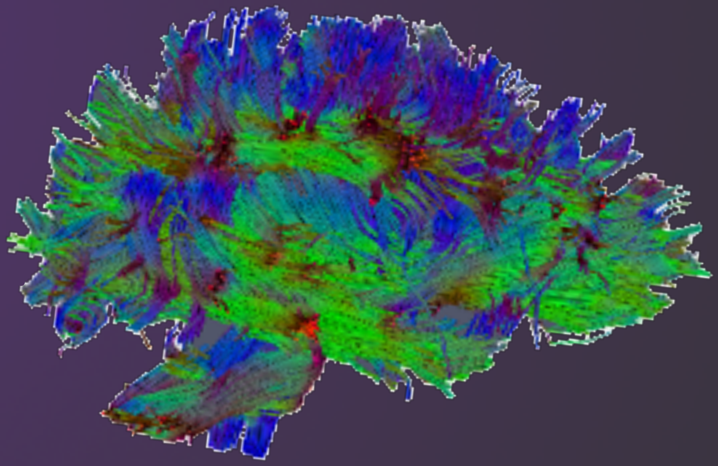


Fiber streamlines

Fiber Conversion

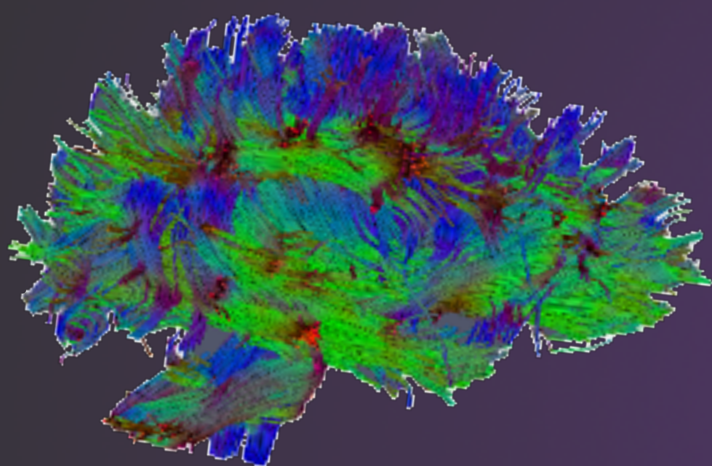


Fiber streamlines

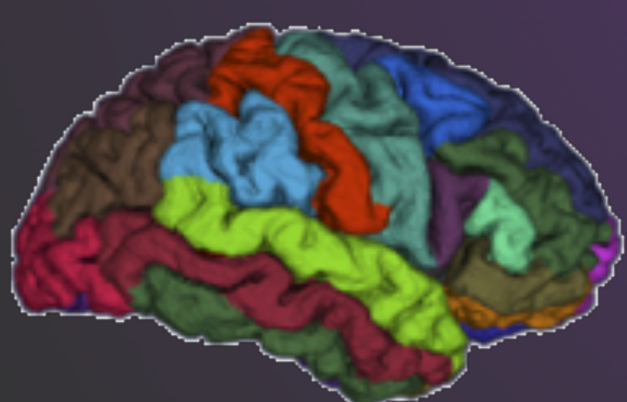


Fiber streamlines

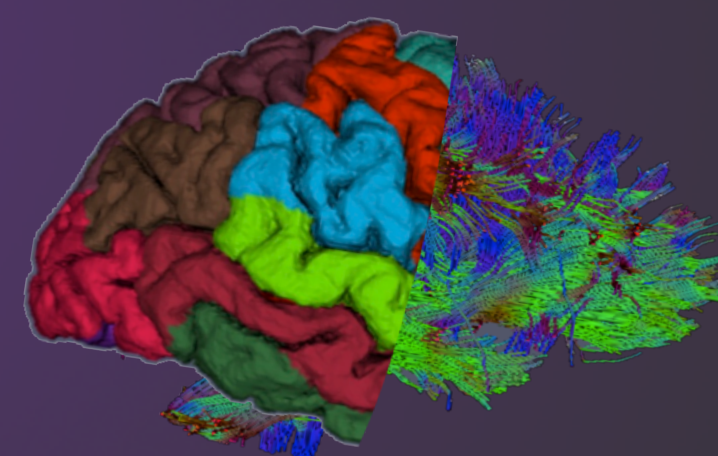
Graph Generation (p1)



Fiber streamlines

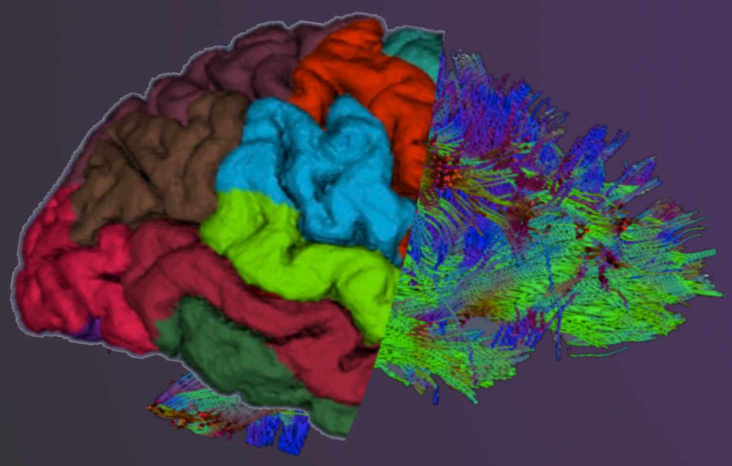


Region labels

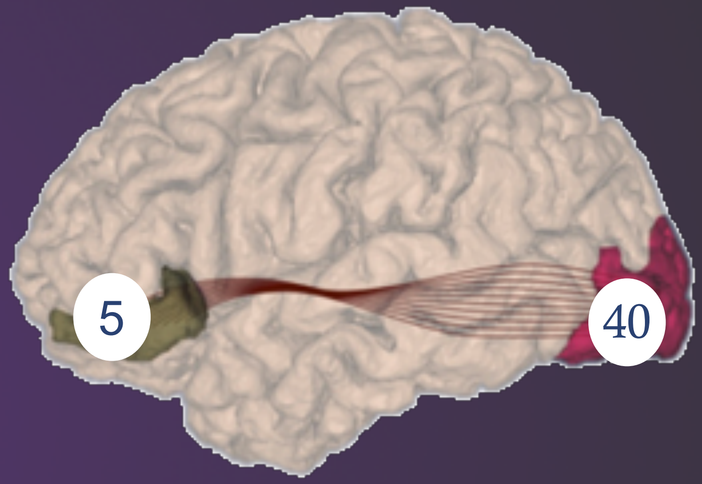


Labeled fibers

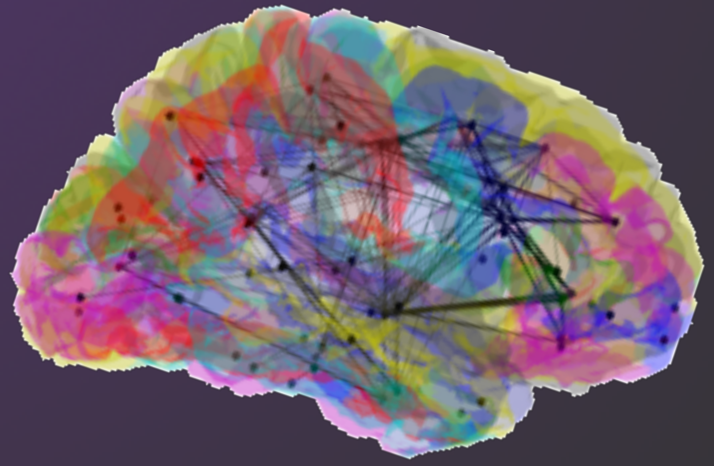
Graph Generation (p2)



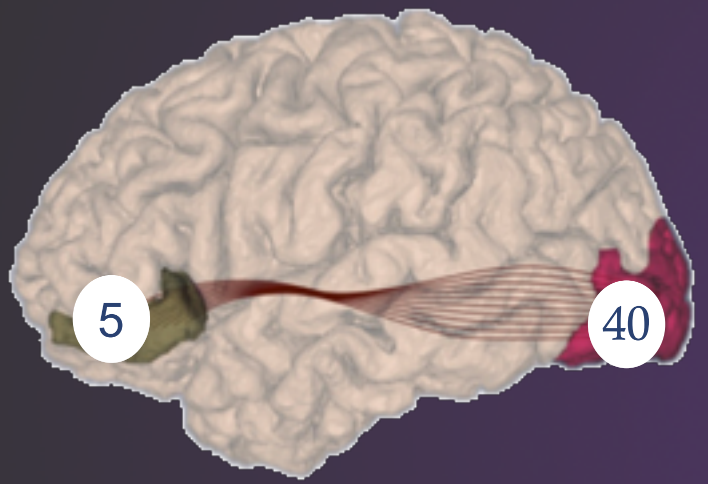
Labeled fibers

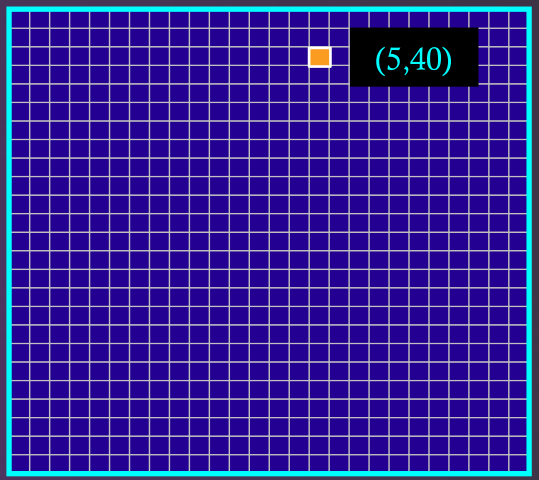


Region Connectivity

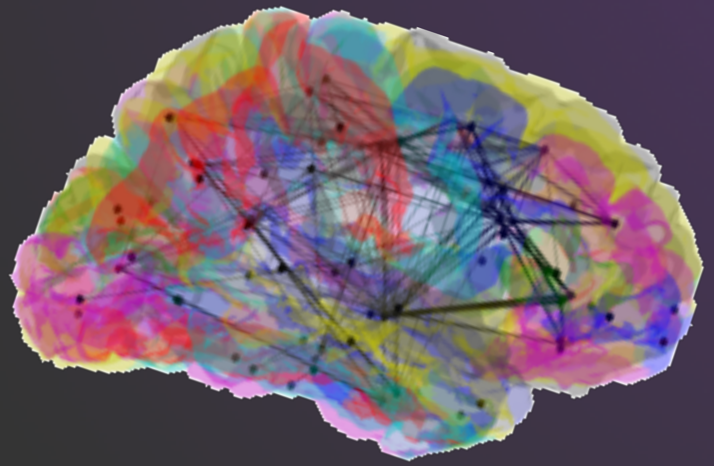


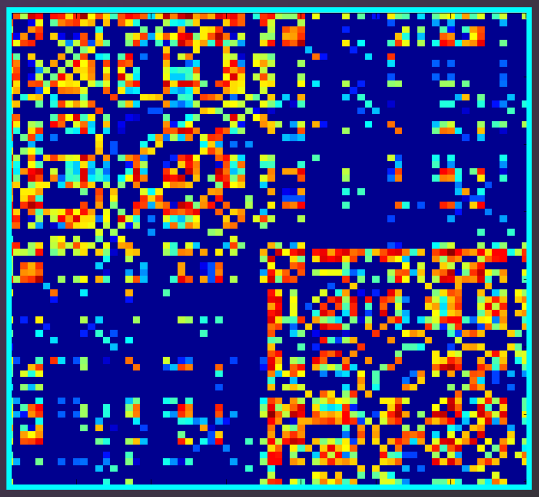
Graph Generation (p3)



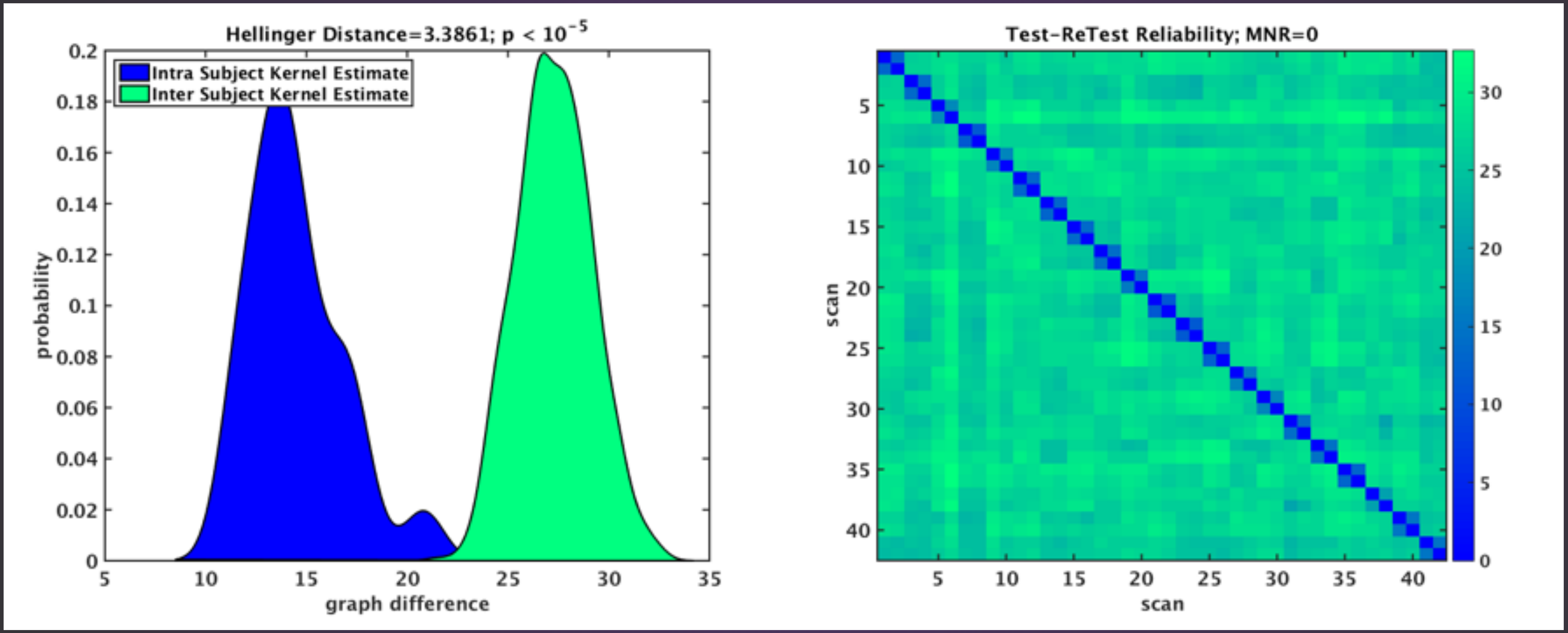


Region Connectivity → Connectivity map





Reliability

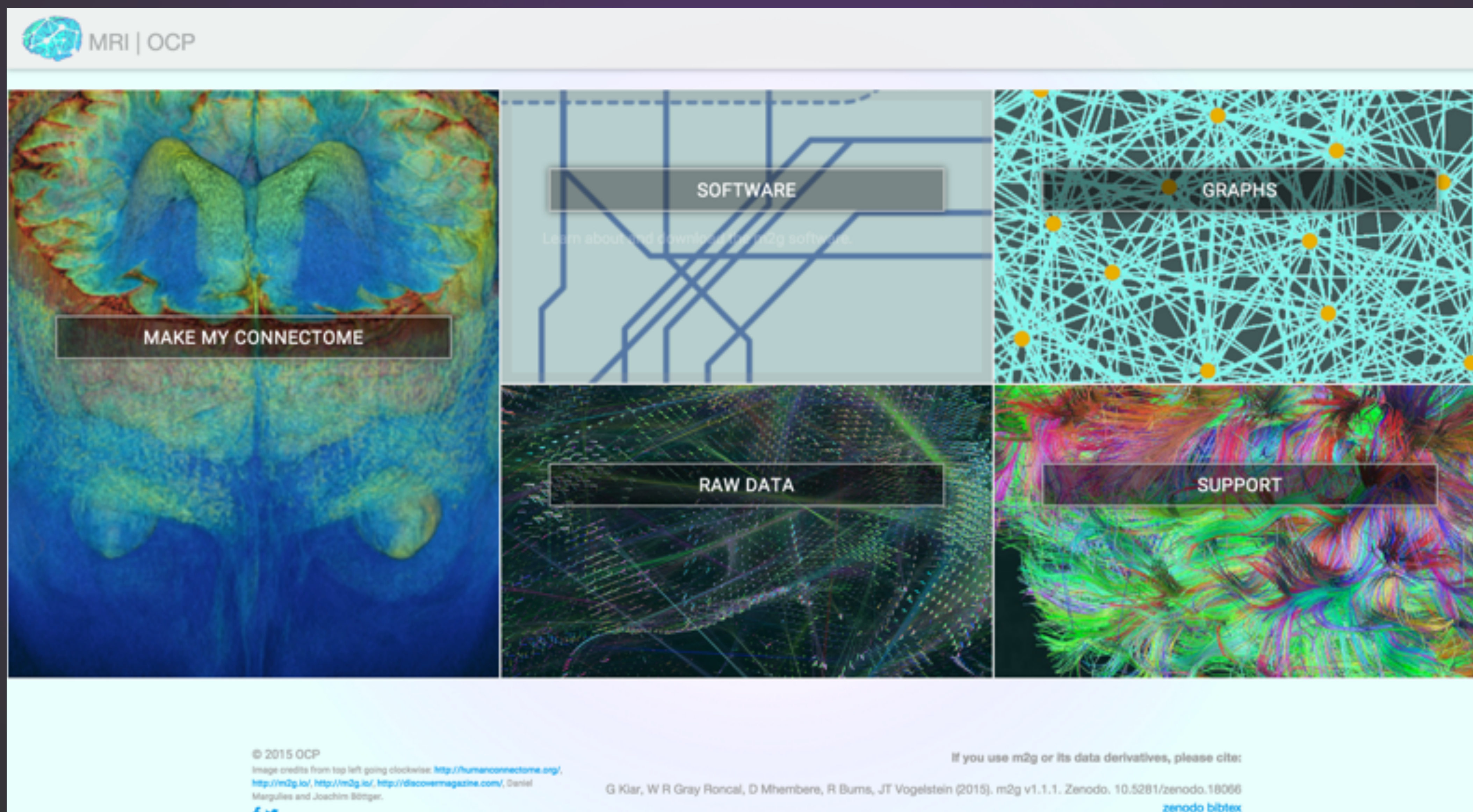


$$R = p\left(\|a_{ij} - a_{ij'}\| \leq \|a_{ij} - a_{i'j'}\|\right)$$

Code

github.com/openconnectome/m2g

Accessible Service



Roadmap

- process all available DTI+T1/MPRAGE datasets
- test and evaluate pipelines to determine optimal operating points
- development of models for inference

the peeps

the groups

Johns Hopkins University (CS, BME, AMS, EE), JHU Applied Physics Laboratory, Duke University (EE), Child Mind Institute, Mind Research Network

the funding

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