Introduction to Neuroimaging

Lecture Notes

Ahmet Ademoglu, *PhD*
Bogazici University
Institute of Biomedical Engineering

Brain Imaging Modalities

- Anatomical/Structural Brain Imaging
  1. Computer Tomography
  2. T1/T2 Weighted MR Imaging
  3. Diffusion Tensor Imaging
- Functional/Physiological Brain Imaging
  1. Positron Emission Tomography (PET) / SPECT
  2. Functional Magnetic Resonance Imaging (fMRI)
  3. EEG/MEG

In PET, it is the blood flow that we indirectly measure

- A tracer (radionuclide) is used and emitted a pair of gamma rays in opposite directions are detected and converted into (sinograms) and reconstructed into tomographic images
- Different tracers allow various properties to be measured;
- O^{15} can measure blood flow relatively quickly (¡1 min) but requires a cyclotron because of its short 2 minute half-life
- F^{18} Fluorodeoxyglucose (FDG) measures glucose metabolism, and has a half life of 110 minutes
- Other tracers exist that bind to interesting receptors (e.g. dopamine, serotonin) or beta-amyloid plaques

Some Disadvantages of PET

1. Slow, even compared to haemodynamic delays
2. Low spatial resolution
3. Ionising radiation

What we measure in fMRI is

Blood oxygen level dependency signal called BOLD

1. With fMRI, we typically acquire a scan every few seconds, and wish to study event-related responses
2. High spatial resolution
3. Low temporal resolution

What we masure in EEG/MEG is

postsynaptic potentials directly related to neuronal activity

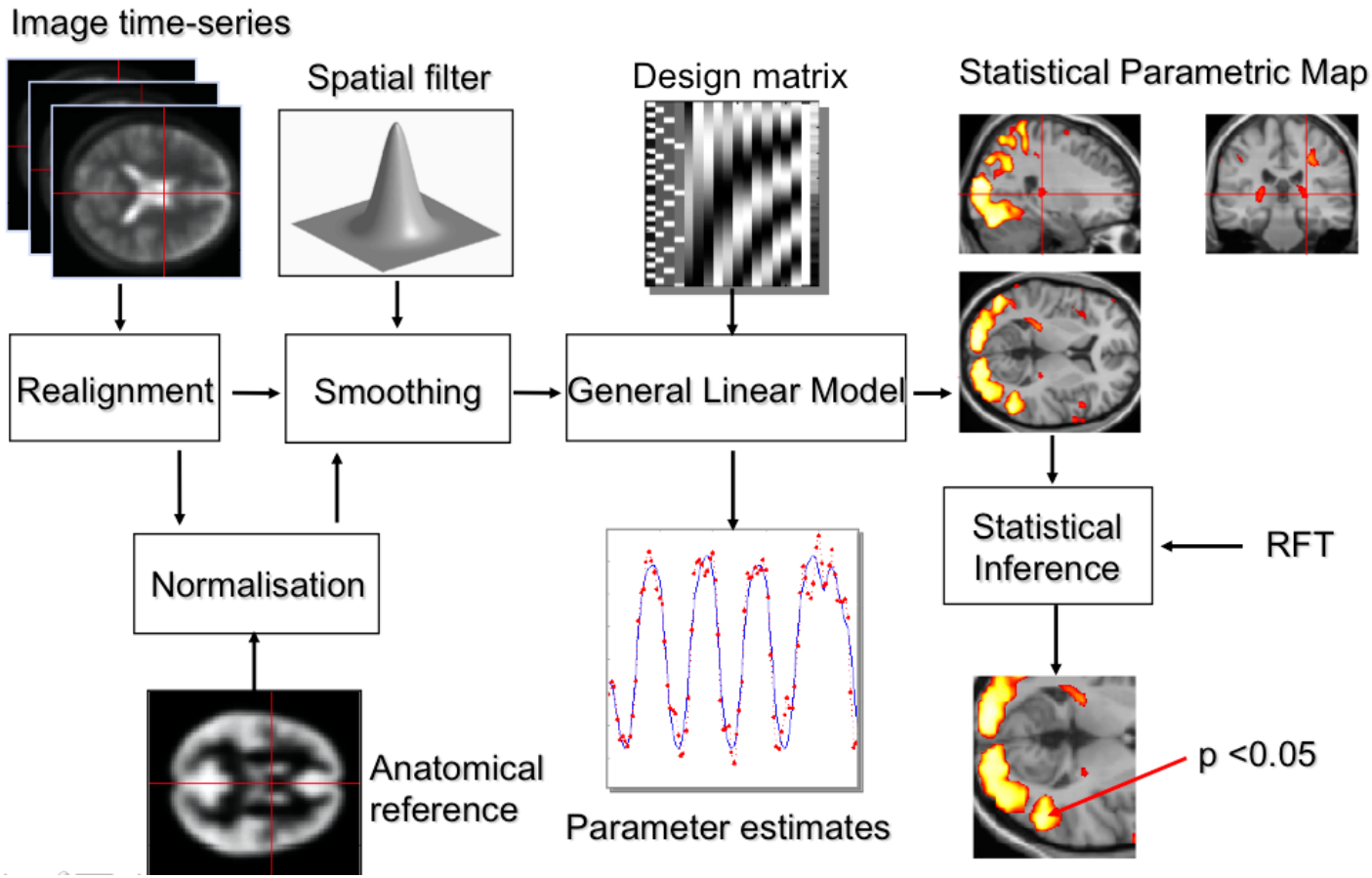
1. High temporal resolution
2. Low spatial resolution

Platforms/Tools for Brain Imaging Data

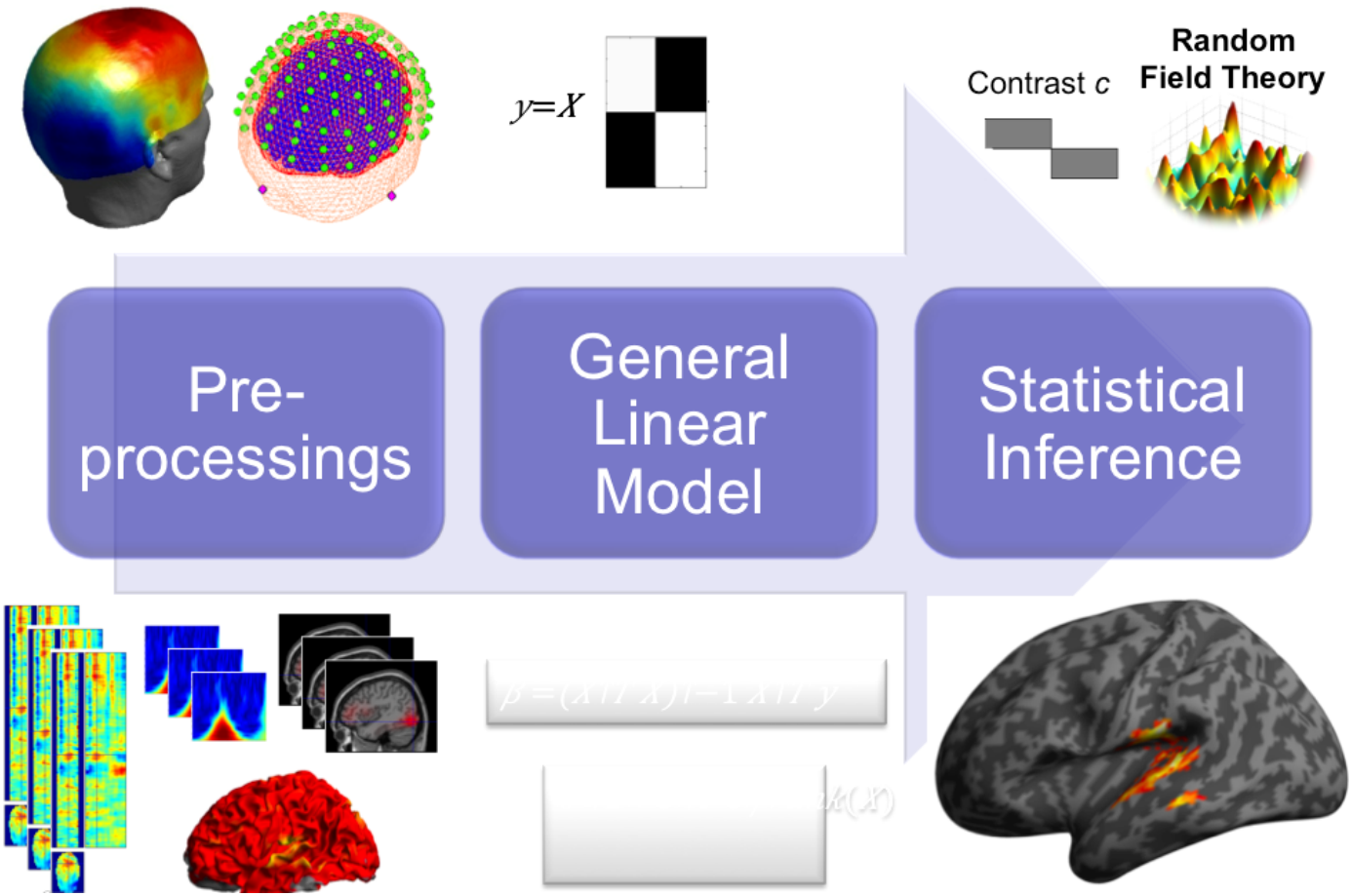
Data Processing, Modeling and Visualization

1. Statistical Parameter Mapping (SPM)
2. AFNI
3. FSL
4. Freesurfer
5. fMRIStat
6. ANTs
7. BrainVisa
8. Caret
9. Neuropy
10. Nilearn
11. fMRIPrep
12. EEGlab
13. Fieldtrip

PET/fMRI Data Processing Stages

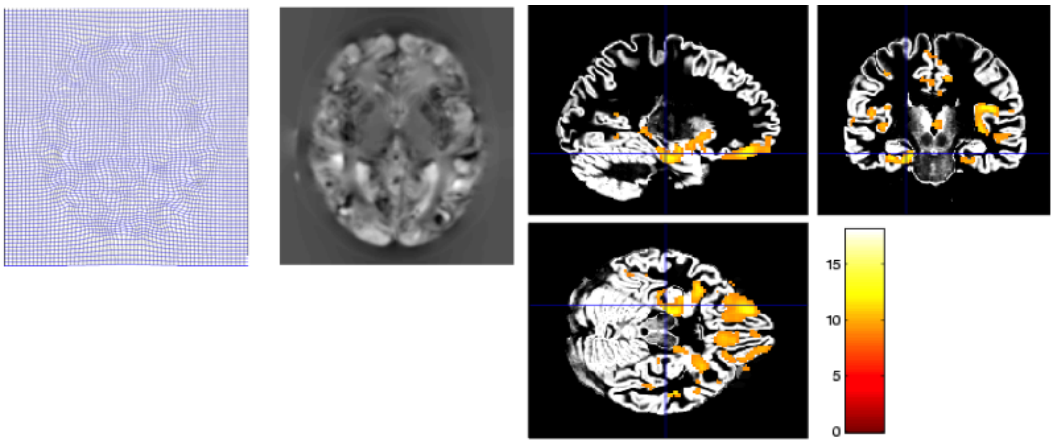


EEG/MEG Data Processing Stages



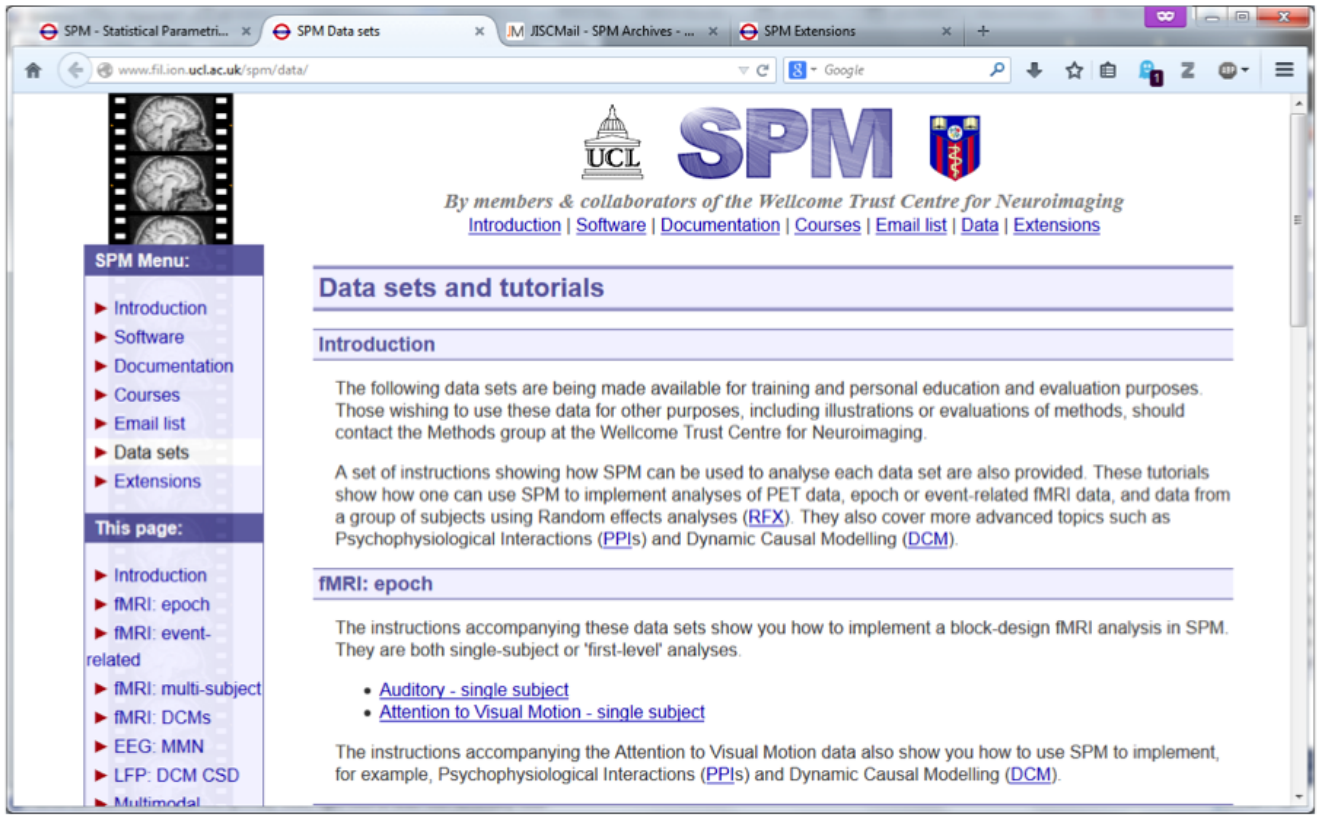
Voxel Based Morphometry (VBM)

- VBM is the most widely used method for computational neuroanatomy.
- Statistical Parametric Mapping of cortical thickness or volume.
- Anatomical changes caused by a disease or a functional distinction.



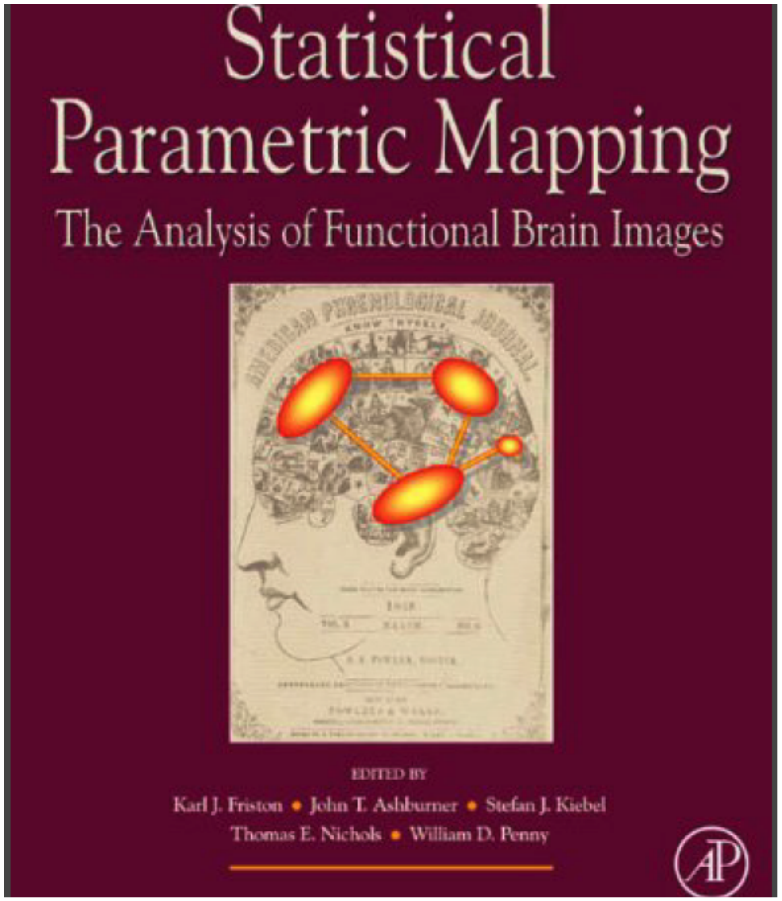
SPM Resources

SPM datasets



PET, fMRI (1st and 2nd level), PPI, DCM, EEG, MEG, LFP.

SPM Resources



SPM12 Manual

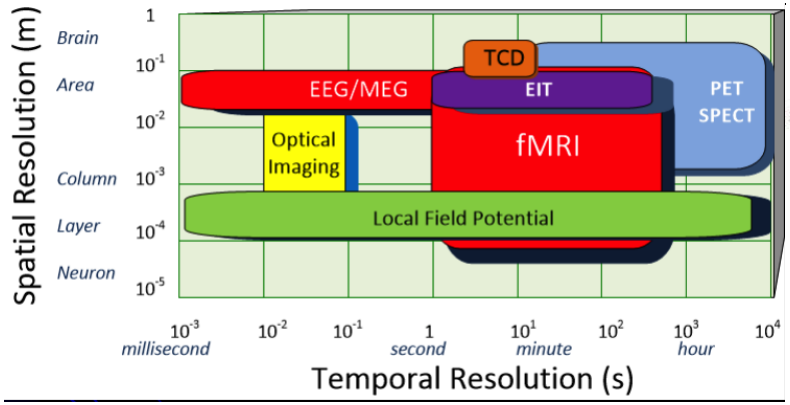
The FIL Methods Group
(and honorary members)

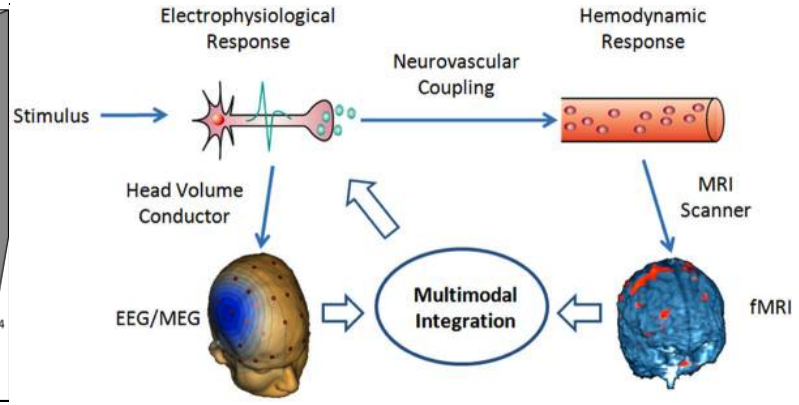
John Ashburner
Gareth Barnes
Chun-Chuan Chen
Jean Daunizeau
Guillaume Flandin
Karl Friston
Stefan Kiebel
James Kilner
Vladimir Litvak
Rosalyn Moran
Will Penny
Adeel Razi
Klaas Stephan
Sungho Tak
Peter Zeidman

Darren Gitelman
Rik Henson
Chloe Hutton
Volkmar Glauche
Jérémie Mattout
Christophe Phillips

Functional Imaging Laboratory
Wellcome Trust Centre for Neuroimaging
Institute of Neurology, UCL
12 Queen Square, London WC1N 3BG, UK
April 13, 2016
http://www.fil.ion.ucl.ac.uk/spm/

MULTIMODAL INTEGRATION





EEG-fMRI Fusion

- Merging the high temporal resolution of EEG/MEG with the high spatial resolution of fMRI.

EEG/fMRI Behavioral Data Fusion

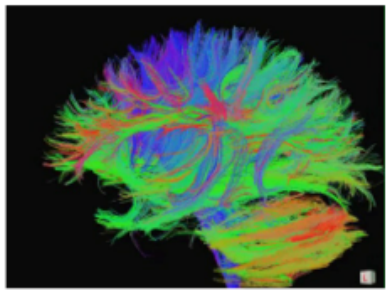
- Merging the EEG/fMRI with the data from behavioral response.

Brain Connectivity

Connectivity

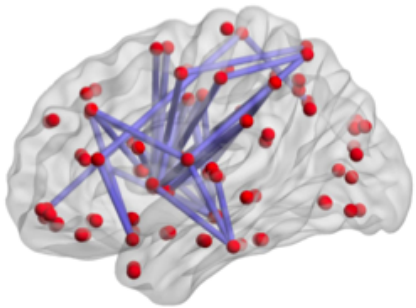
- Structural Connectivity

  Physical connections of the brain



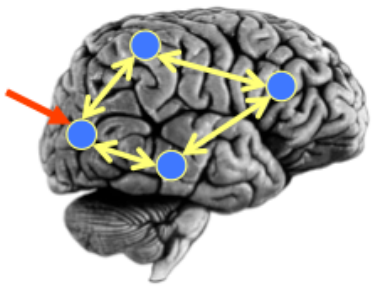
- Functional Connectivity

  Dependencies between BOLD observations

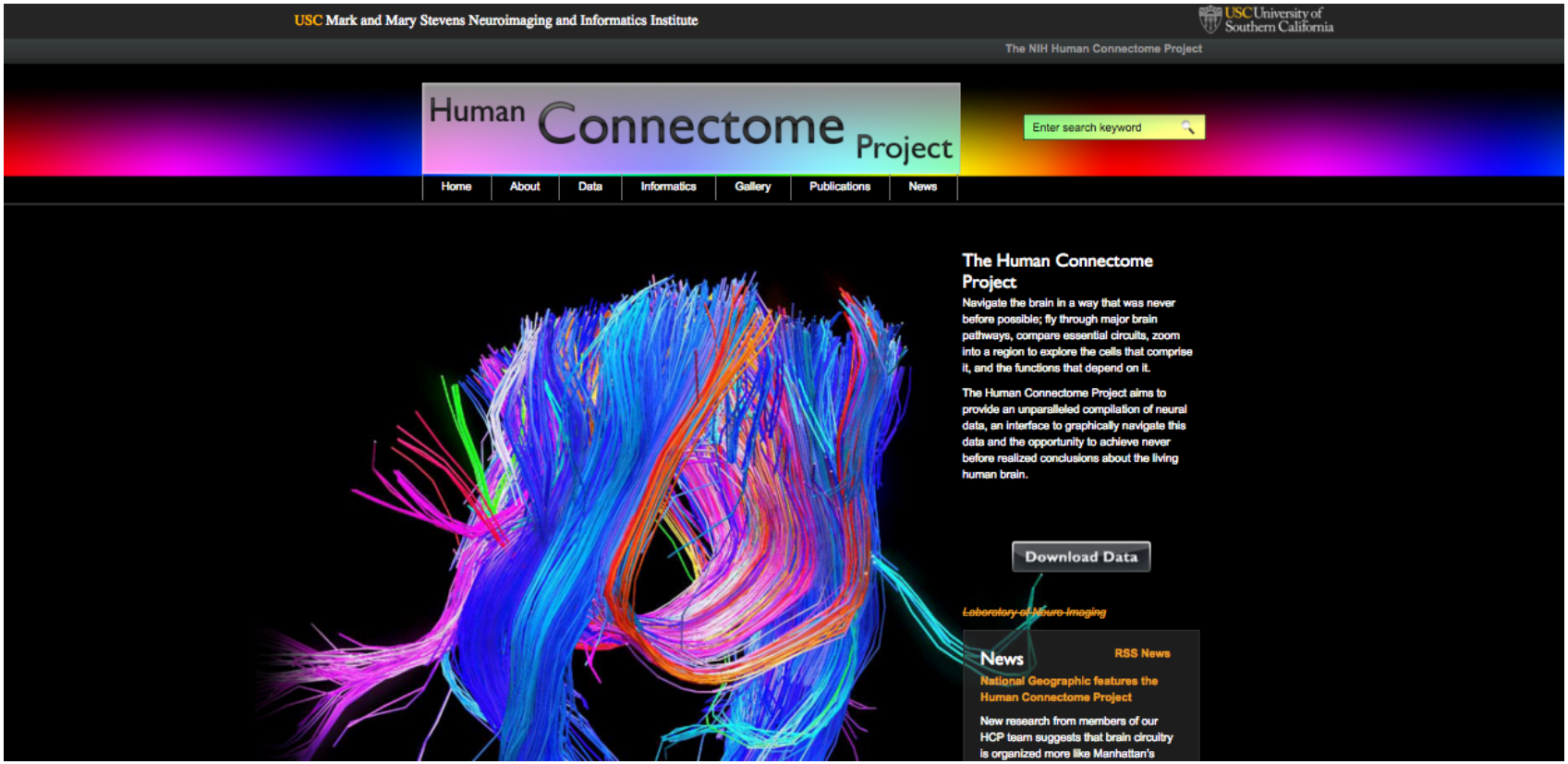


- Effective Connectivity

  Causal relationships between brain regions



Human Connectome Project



Human Connectome Project