

Analysis of Graph Theoretic Properties of Structural and Functional Brain Networks Constructed from fMRI data

Shubham Tripathi and Vijay Keswani

Course Project for SE367A

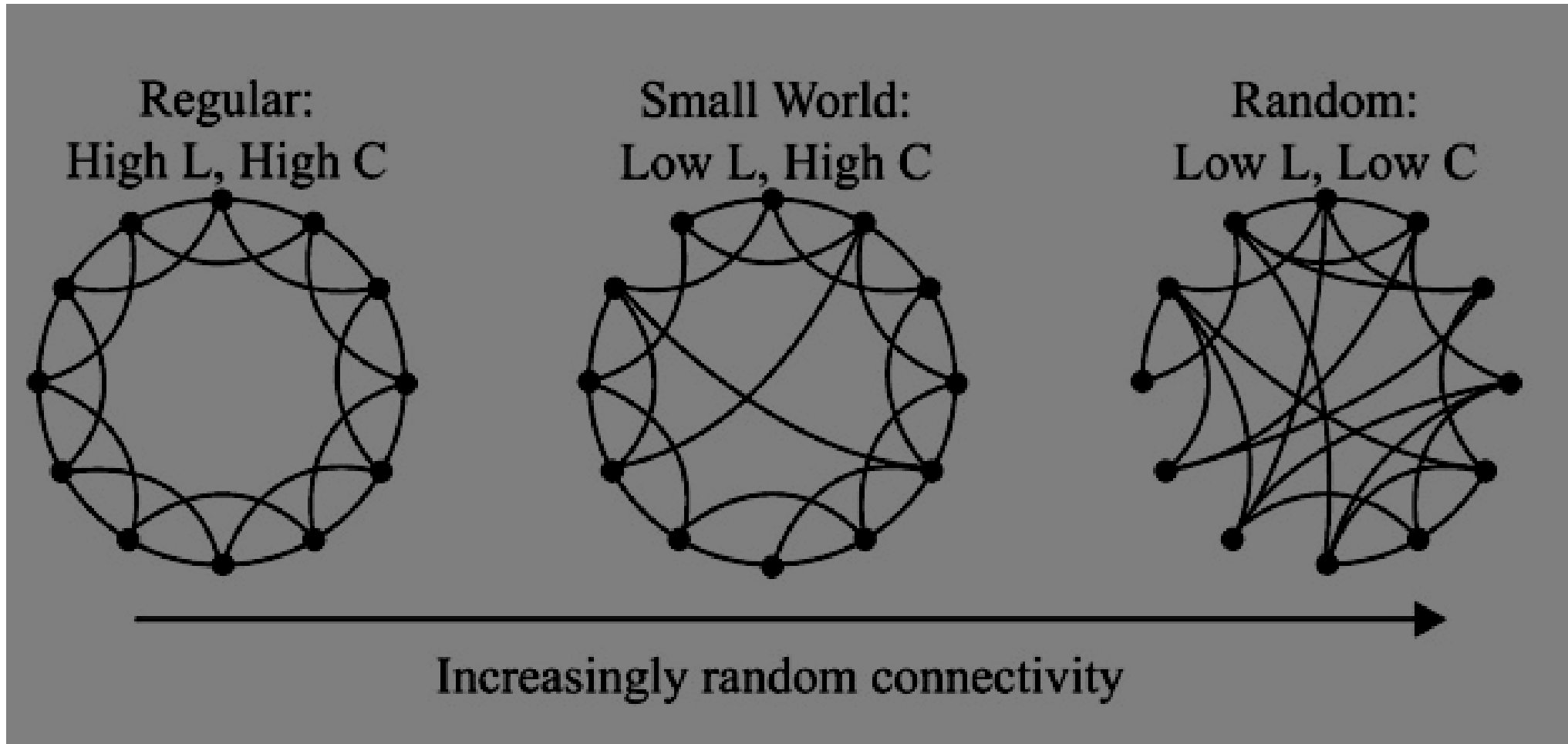
Network Properties of the Brain

- Small-world network topology of the brain
- High information transfer efficiency at low wiring costs
- Highly connected hub regions
- Salvador R, et al (2006), Wang L, et al (2009) and many others have recently used large volume of fMRI data to prove that the brain has above network properties.

Small-World Topology

- Characteristic path length : Average of shortest paths b/w all pairs of nodes in the graph
- Clustering coefficient of a node : (Number of neighbours / total nodes); a popular measure of interconnectivity of a network
- A small-world network has short characteristic path length but high clustering coefficient.

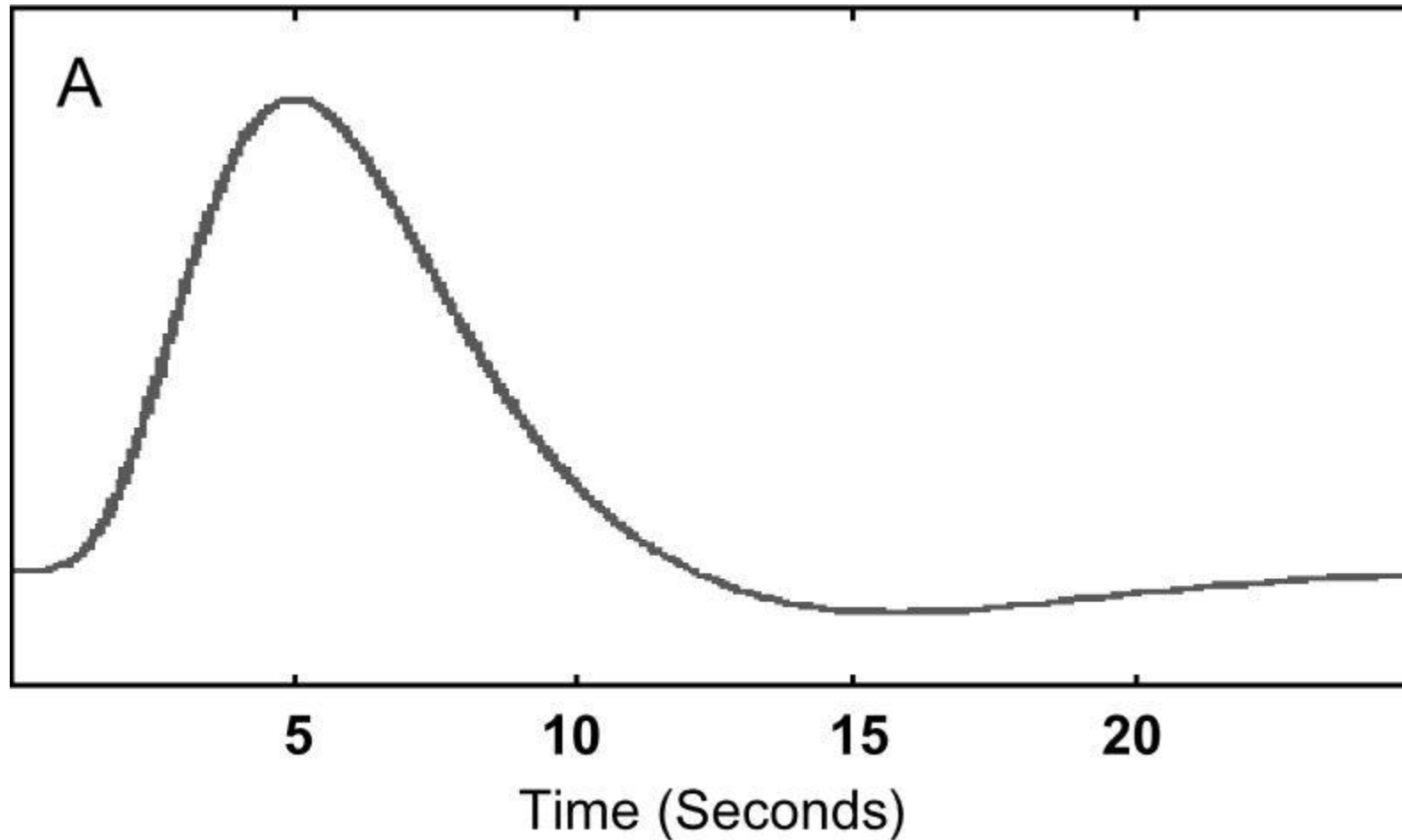
Small-World Topology



BOLD fMRI

- BOLD stands for Blood Oxygen Level Dependent.
- This technique is based on monitoring the levels of oxygenated and deoxygenated blood in successive brain slices that are excited with a radio pulse in the presence of a strong magnetic field (0.3 tesla to 7 tesla).
- The entire brain volume is mapped several times over a period of time, with each imaging cycle usually taking about 2 seconds (TR).
- fMRI data file for a patient consists of activation levels at any point of time for about 1,00,000 brain voxels (3D cubical regions into which the brain is divided)

Hemodynamic Response Function



fMRI Datasets



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Data Sets

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Study	Investigators	Accession Number
Balloon Analog Risk-taking Task	Tom Schonberg	ds000001
Classification learning	Aron, A.R.	ds000002
Rhyme judgment	Xue, G.	ds000003
Mixed-gambles task	Tom S.M.	ds000005
Living-nonliving decision with plain or mirror-reversed text	K Jimura	ds000006
Stop-signal task with spoken & manual responses	Xue G	ds000007

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List of Data by Category

Human Functional Imaging Data

The following are large and diverse datasets collected as part of the MBIRN and FBIRN collaboratories and throughout clinical imaging communities at large.

- [BrainScope_BS002 – BrainScope Resting State fMRI Dataset 1](#)

This dataset includes seventeen healthy subjects with four resting state fixation scans plus one T1 scan and one T2 scan.

- [BrainScope_BS003 – BrainScope Resting State fMRI Dataset 2](#)

This dataset includes ten healthy subjects scanned 3 times with 3 conditions: eyes open, eyes closed, and fixating in addition to two anatomical scans (T1 and T2).

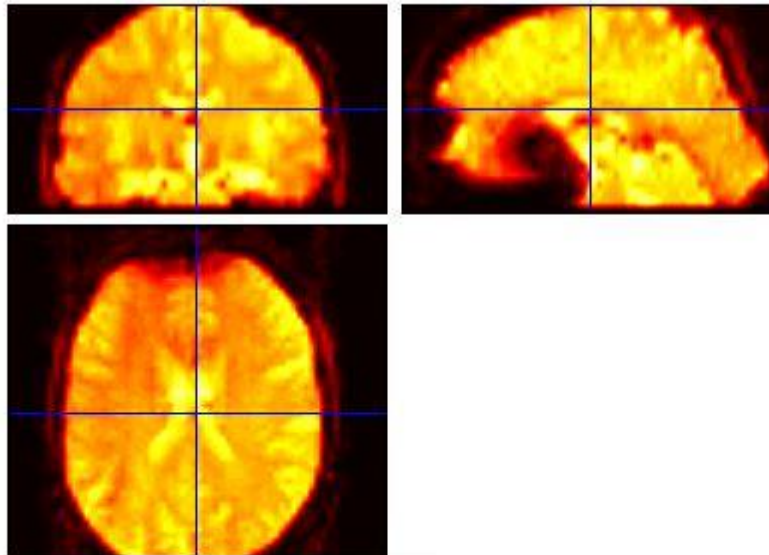
- [fBIRN Phase 1 – Traveling subjects study](#)

This dataset includes five healthy subjects imaged twice at each of ten FBIRN MRI scanners on successive days.

- [fBIRN Phase 2 – Neuroimaging Calibration Study](#)

The FBIRN multi-site dataset of subjects with schizophrenia and controls includes functional MRI images, behavioral data, demographic, and clinical assessments on 253 subjects from around the US.

SPM12 (6225): Graphics

Crosshair Position

mm:

vx:

Intensity:

right {mm}	0
forward {mm}	0
up {mm}	0
pitch {rad}	0
roll {rad}	0
yaw {rad}	0
resize {x}	1
resize {y}	1
resize {z}	1

File: \arsM03953_0005_0008.img

Dimensions: 64 x 64 x 24

Datatype: int16

Intensity: Y = 0.052797 X

spm - realigned acq-fix ref-slice 12

Vox size: -3 x 3 x 4.5

Origin: 32.5 32.3 12.5

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0.000 0.000 1.000

Full Volume World Space Auto Window ... Trilinear interp.

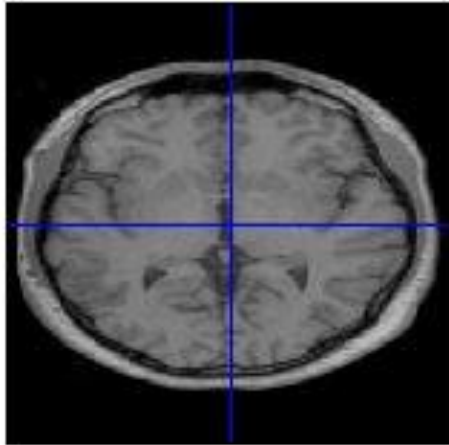
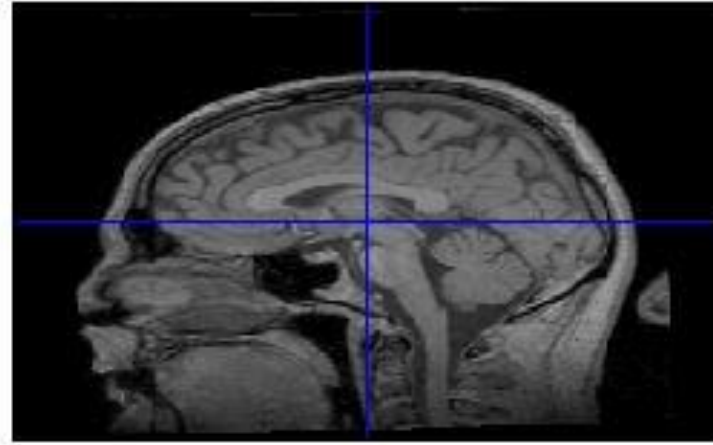
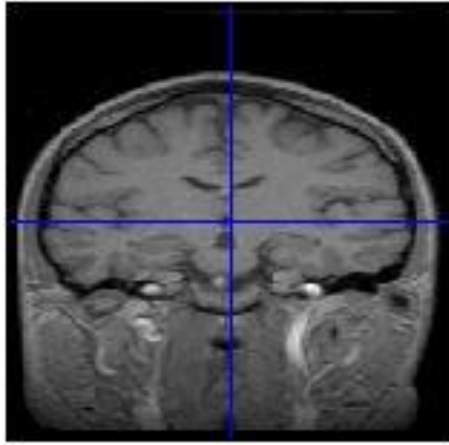
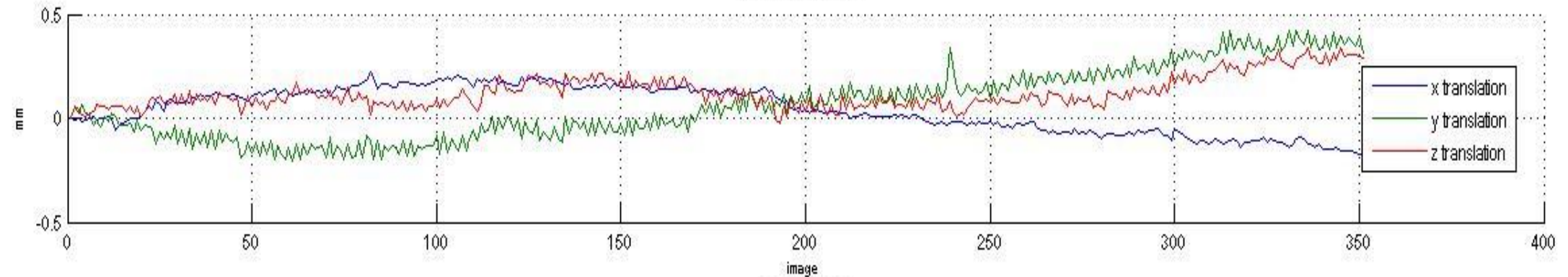


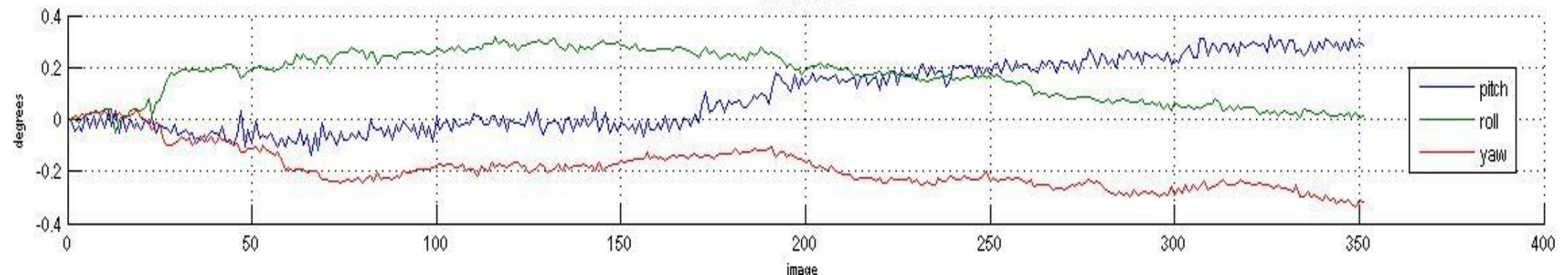
Image realignment

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3 C:\Users\Shubham.Tripathi\Documents\fmri\face_rep\RawEPI\sM03953_0005_0008.img,1
4 C:\Users\Shubham.Tripathi\Documents\fmri\face_rep\RawEPI\sM03953_0005_0009.img,1
5 C:\Users\Shubham.Tripathi\Documents\fmri\face_rep\RawEPI\sM03953_0005_0010.img,1
6 C:\Users\Shubham.Tripathi\Documents\fmri\face_rep\RawEPI\sM03953_0005_0011.img,1
7 C:\Users\Shubham.Tripathi\Documents\fmri\face_rep\RawEPI\sM03953_0005_0012.img,1
8 C:\Users\Shubham.Tripathi\Documents\fmri\face_rep\RawEPI\sM03953_0005_0013.img,1
9 C:\Users\Shubham.Tripathi\Documents\fmri\face_rep\RawEPI\sM03953_0005_0014.img,1
10 C:\Users\Shubham.Tripathi\Documents\fmri\face_rep\RawEPI\sM03953_0005_0015.img,1
11 C:\Users\Shubham.Tripathi\Documents\fmri\face_rep\RawEPI\sM03953_0005_0016.img,1
12 C:\Users\Shubham.Tripathi\Documents\fmri\face_rep\RawEPI\sM03953_0005_0017.img,1
.....etc
```

translation



rotation



BOLD fMRI Data Model

$$y_{ij}(t) = \sum_{g=1}^G z_{ijg}(t) \gamma_{ijg} + \sum_{k=1}^K x_{ijk}(t) \beta_{ijk} + \varepsilon_{ij}(t)$$

Functional Brain Connectivity

- Principal Component Analysis or Independent Analysis can be utilized to extract functional brain connectivity information from fMRI data.
- We then utilize this information to model the brain as a graph.

References

- Martin A. Lindquist (2008). The Statistical Analysis of fMRI data. *Statistical Science Vol. 23 No. 4 439-464.*
- Salvador R, Suckling J, Coleman MR, et al. (2005] *Neurophysiological architecture of functional magnetic resonance images of human brain.*
- Cole MW, Pathak S, Schneider W. (2010) *Identifying the brain's most globally connected regions.*
- Van den Heuvel MP, Stam CJ, Kahn RS (2009) *Efficiency of functional brain networks and intellectual performance.*
- Supekar K, Menon V, Rubin D, et al (2008) *Network analysis of intrinsic functional brain connectivity in Alzheimer's disease.*

Thank You!