

Lecture 04

- Password for book chapters
- Mathematical Preliminaries, Matlab Primer, Matrix Primer
- Image File Formats
- Overview of Software Packages
- Introduction to two Matlab Software Packages

$$\langle \vec{x}, \vec{y} \rangle = \sum_k x_k y_k^* = \vec{x}^T \vec{y}^* \quad \text{and} \quad \|\vec{x}\|^2 = \langle \vec{x}, \vec{x} \rangle$$

Inner Product & Norm

$$r = \frac{\langle \vec{X}, \vec{Y} \rangle}{\|\vec{X}\| \|\vec{Y}\|}$$

Correlation

where $\vec{A} = \vec{a} - \bar{a}$ with $\bar{a} = \sum_{k=1}^K a_k / K$ and where $\|\vec{A}\| \equiv \sigma_a$ the standard deviation of \vec{a} (see Equation (1.3)). The quantity $\langle X, Y \rangle$ is the covariance between \vec{X} and \vec{Y} (or \vec{x} and \vec{y}). The cross-correlation and convolution of two vectors in ℓ^2 may be

$$(F\vec{x})_k = \sum_{j=1}^n x_j e^{-2\pi i k j} \quad \text{and} \quad (F^{-1}\vec{x})_k = \sum_{j=1}^n x_j e^{2\pi i k j}$$

Fourier Transform & Inverse Fourier Transform

$$\vec{x} * \vec{y} = \sum_k x_k y_{j-k}$$

Convolution

$$\mathcal{F}(g * f) = (\mathcal{F}g)(\mathcal{F}f) \quad \text{and} \quad \mathcal{F}(\vec{g} * \vec{f}) = (\mathcal{F}\vec{g})(\mathcal{F}\vec{f}).$$

Convolution Theorem

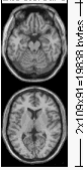
Image File Formats

- DICOM
- Analyze
- Nifti

DICOM

The Digital Imaging and Communications in Medicine (DICOM) standard was created by the National Electrical Manufacturers Association (NEMA) to aid the distribution and viewing of medical images

DICOM Header
 Frames: 2
 Rows: 109
 Columns: 91
 Bits stored: 8



MRI *

First 128 bytes: unused by DICOM format
 Followed by the characters 'D','I','C','M'
 This preamble is followed by extra information e.g.:

```

0002.0000 File Meta Elements Group Len: 132
0002.0001 File Meta Info Version: 256
0002.0010 Transfer Syntax UID: 1.2.840.10008.1.2.1
0008.0000 Identifying Group Length: 152
0008.0060 Modality: MR
0008.0070 Manufacturer: MRICro
0018.0000 Acquisition Group Length: 28
0018.0050 Slice Thickness: 2.00
0018.1020 Software Version: 46V437
0028.0000 Image Presentation Group Length: 148
0028.0002 Samples Per Pixel: 1
0028.0004 Photometric Interpretation: MONOCHROME2
0028.0008 Number of Frames: 2
0028.0010 Rows: 109
0028.0011 Columns: 91
0028.0030 Pixel Spacing: 2.00;2.00
0028.0100 Bits Allocated: 8
0028.0101 Bits Stored: 8
0028.0102 High Bit: 7
0028.0103 Pixel Representation: 0
0028.1052 Rescale Intercept: 0.00
0028.1053 Rescale Slope: 0.0032157
7FE0.0000 Pixel Data Group Length: 19850
7FE0.0010 Pixel Data: 19838

```

Analyze

- Analyze format
- .img Raw, binary data; 3D or 4D
- .hdr Small binary header
 - Image dimension
 - Voxel size
 - Origin, in voxels
 - First element 1, not 0
- .mat Optional, SPM2 extension (depricated in SPM5!)
 - Defines transformation from voxel to world space
 - If exists, .hdr voxel size & origin are ignored
 - Origin can be represented as mm location
 - e.g. between voxels

NifTI

- .img + .hdr
 - Like Analyze, but different .hdr definition
 - different
- .nii *Single file!*
 - Header and Image file concatenated
 - SPM can read .nii files, but doesn't write them
- World space transformation coded in NIFTI header
 - No more (image) .mat files!

Software Packages

- **AFNI** (<http://afni.nimh.nih.gov/afni>): A set of programs for processing, analyzing, and displaying functional MRI (fMRI) data. It runs on Unix-based systems and is currently freely available.
- **FSL** (<http://www.fmrib.ox.ac.uk/fsl/>): FSL is a comprehensive library of image analysis and statistical tools for FMRI, MRI and DTI brain imaging data. FSL is written mainly by members of the Analysis Group, FMRI, Oxford, UK.
- **FreeSurfer** (<http://surfer.nmr.mgh.harvard.edu/>): A program for reconstruction of the brain's cortical surface and overlay of functional data onto the reconstructed surface, the program is developed by Martin Sereno.
- **SPM** (<http://www.fil.ion.ucl.ac.uk/spm/>): A powerful set of MATLAB functions for preprocessing, analysis, and display of fMRI and PET data. It is currently freely available.
- **IMSIM** (http://learnfmri.ucsd.edu/index.php?option=com_content&task=view&id=16&Itemid=38): A MATLAB tool to simulate MRI Imaging - developed inhouse at the UCSD fMRI center.
- **VoxBo** (<http://www.voxbo.org/>): A package that contains both analysis tools and project management features for tracking the status of analyses. It runs on Unix-based systems and is currently freely available.

Software Packages

- **Stimulate** (<http://www.cmrr.umn.edu/stimulate/>): An fMRI analysis package that runs on UNIX / Linux based systems. It is currently freely available.
- **MEDx** (<http://medx.sensor.com/products/medx/index.html>): A software package for the visualization, processing, and analysis of medical images. It is a commercial product.
- **BrainVoyager** (<http://www.brainvoyager.com/>): A Windows-compatible fMRI analysis and visualization software that includes very powerful rendering functions. It is a commercial product.
- **MRIcro** (<http://www.sph.sc.edu/comd/rorden/micro.html>): An easy to use program that allows Windows and Linux computers to view medical images. It is a stand-alone program, but includes tools to complement SPM. It is currently freely available.
- **ImageJ** (<http://rsb.info.nih.gov/ij/>): A versatile easy to use program for viewing and analyzing any digital images (including MRI). Java-based program works under windows, mac or linux.
- **GIFT** (<http://icatb.sourceforge.net/>): A matlab toolbox which implement single subject and group independent component analysis, a data driven approach.

- Two Complementary Software Packages

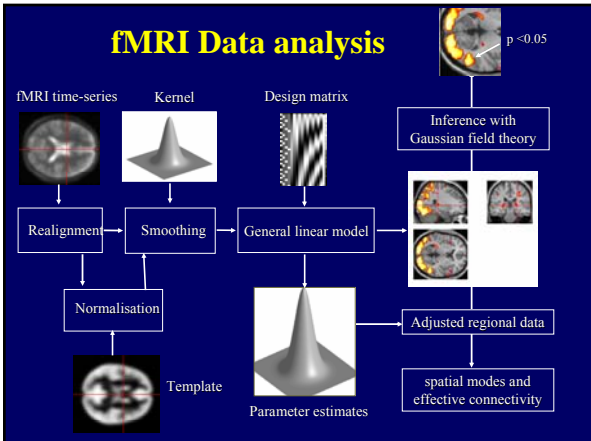


SPM5
Implements General Linear Model
(Model-Based, Univariate)



GIFT
Implements Independent Component Analysis
(Data-Driven, Multivariate)

fMRI Data analysis



Intro to Statistical Parametric Mapping

Statistical Parametric Mapping (SPM)

- Started in 1991 in response to PET studies
 - Regions of Interest (ROIs);
 - Tons of data to a few regions;
 - poor use of data; localization; reproducibility
- Made publicly available in 1994 (SPMclassic)
- SPM94 - PET
- SPM95 – PET/fMRI
- SPM96 – Major revision
- SPM97 – Event-related fMRI
- SPM99 - Major revision
- SPM2 – Major revision
- SPM5 – Latest release

Intro to Statistical Parametric Mapping

Advantages

- Free
- Relatively easy to use (help list)
- Platform independent (matlab)
- Can be (relatively) easily modified
- 10 different people involved in coding
- 100s of users
- modules are subjected to peer review
- customizable – edit/tool boxes/etc.

Intro to Statistical Parametric Mapping



Intro to Statistical Parametric Mapping

