Practice in resting-state fMRI (rs-fMRI) Analysis: PART II

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Course Arrangement

PART I
- REST toolbox http://restfmri.net/forum/index.php?q=rest
- ReHo, ALFF, fALFF, Statistics

PART II
- REST toolbox
- Functional connectivity (seed-based, atlas-based)
- FC strength mapping

Employed Packages

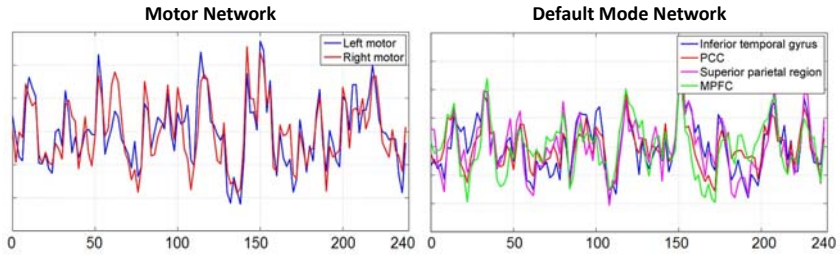
1. **REST** functional connectivity, ReHo, ALFF, fALFF
   - http://restfmri.net/forum/index.php?q=rest
2. **IBASPM 64-bit**
   - http://www.ym.edu.tw/~cflu/software/Ibaspm_64.zip

fMRI Study

- Functional **segregation** ⇔ functional **integration**
- Functional integration is the study of connected processes.
- **Functional connectivity** → finding statistical patterns of relationships
- **Effective connectivity** → modeling how regions interacts

Definition

- Functional connectivity (FC) is defined as the statistical association or dependency *among two or more anatomically distinct time-series* (Friston 1994, HBM 20, 56-78 & Friston et al., 1996,Cereb Cortex, 60 156-164).



Functional Connectivity: what for?

- In FC analyses, it does not tell how regions are coupled! Because it only test some form of correlation against the null hypothesis.
- FC is however useful to discover patterns (which regions are coupled), and compare patterns, especially between groups

Friston 2011 Functional and Effective Connectivity: A Review. Brain Connectivity, 1, 13-36

Dependencies of time-series

- Correlations and cross-correlation of time series
  - Biswal et al., 1995, Mag Res Med., 34, 537-541
- Cross-coherence
  - Sun et al., 2004, NeuroImage, 21, 647-658
- Mutual information
  - Jeong et al., 2001, Clin Neurophysiol, 1120, 827-835

Functional Connectivity Analysis using REST toolbox

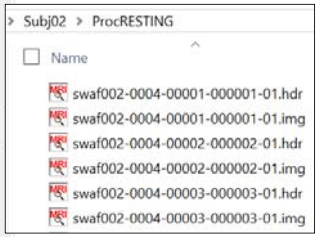
Functional Con.

Select folder of Subj01_filtered (No need to apply filter and mask again)

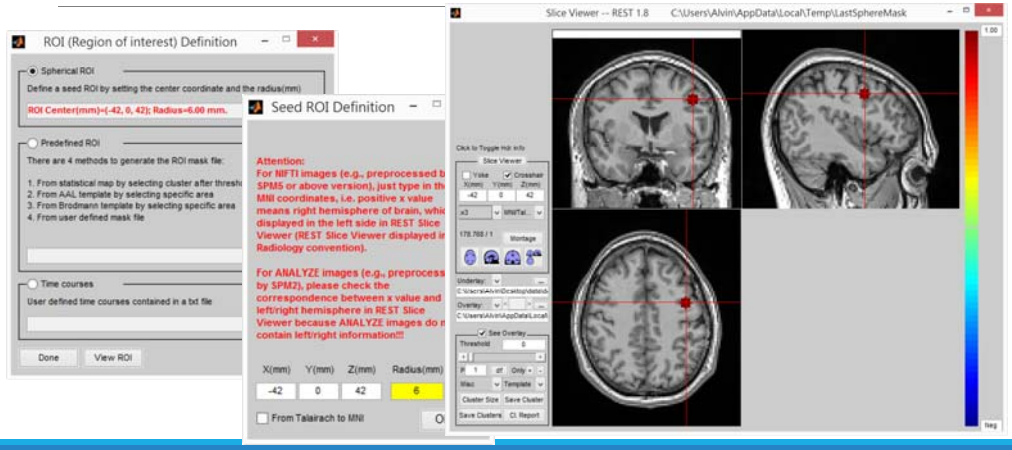
Voxel wise ⇔ ROI wise

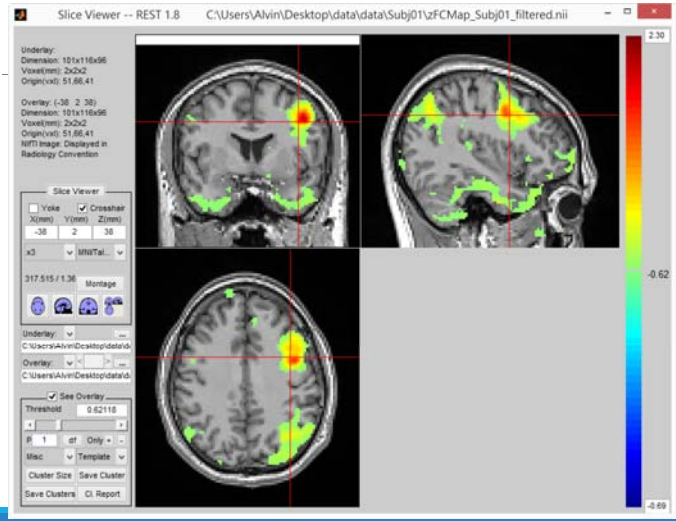
6 motion parameters as covariates

Only put fMRI smooth data in this folder!

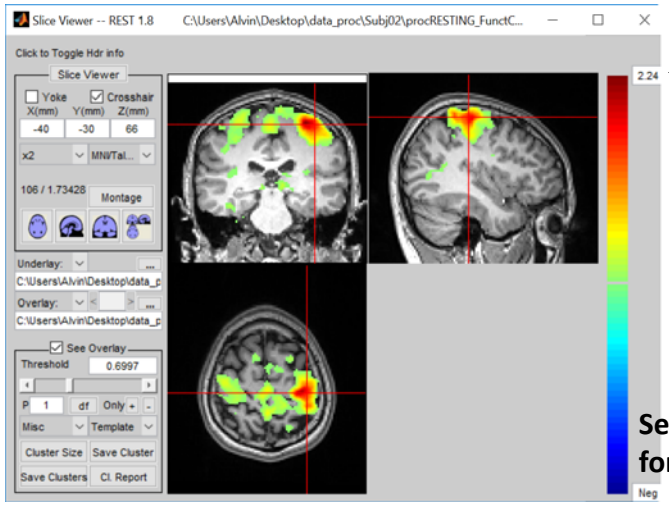


Spherical ROI





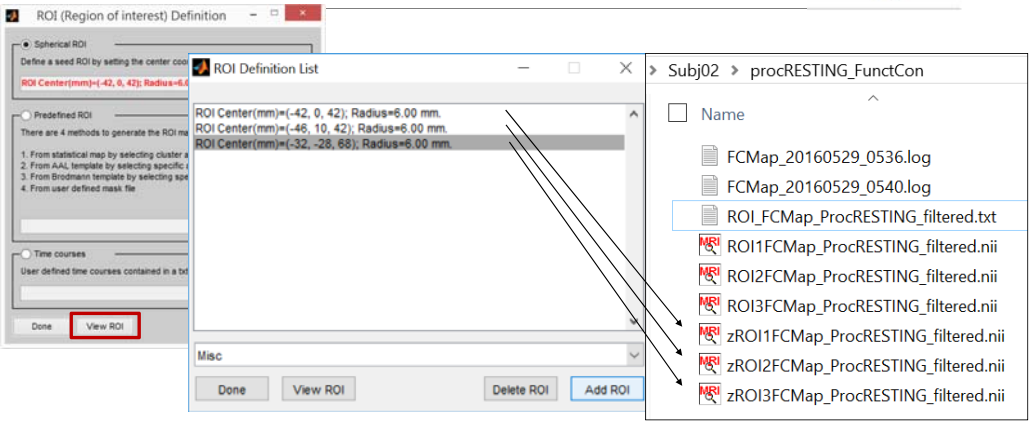
Left ECN for example



Sensorimotor network for example

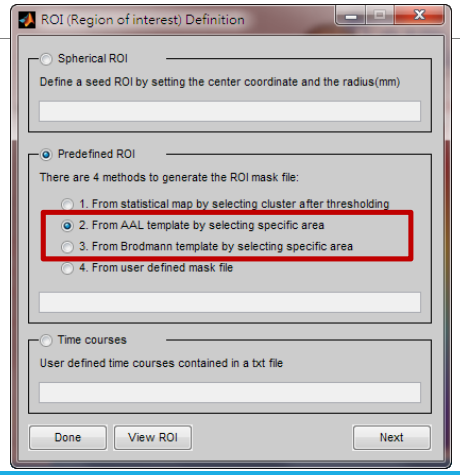
FunctCon

Functional Connectivity Maps



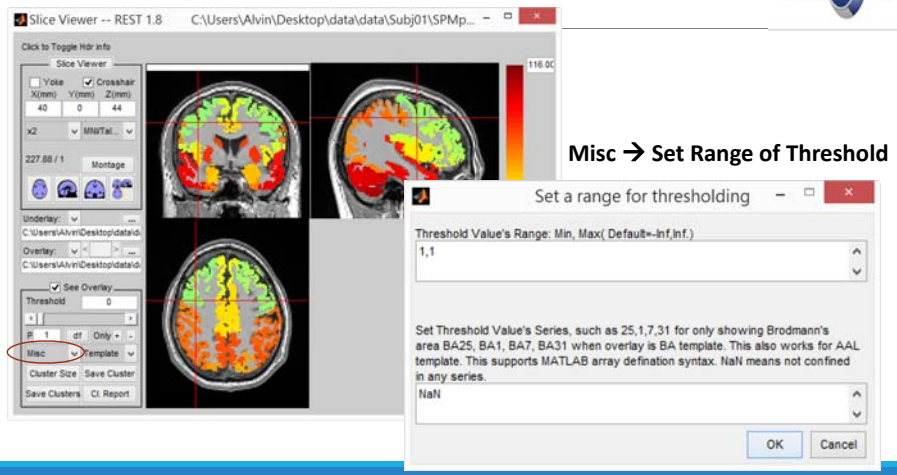
FunctCon

Atlas ROI



FunctCon

Atlas ROI



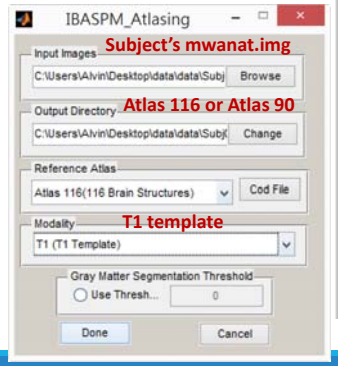
Extract Subject's Atlas

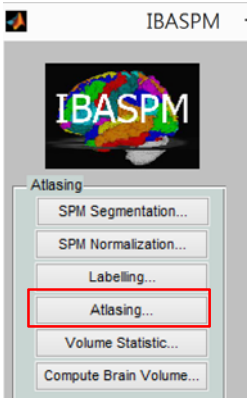
Only include the root folder of IBASPM!!

IBASPM 64-bit version

http://www.ym.edu.tw/~cflu/software/Ibaspm_64.zip

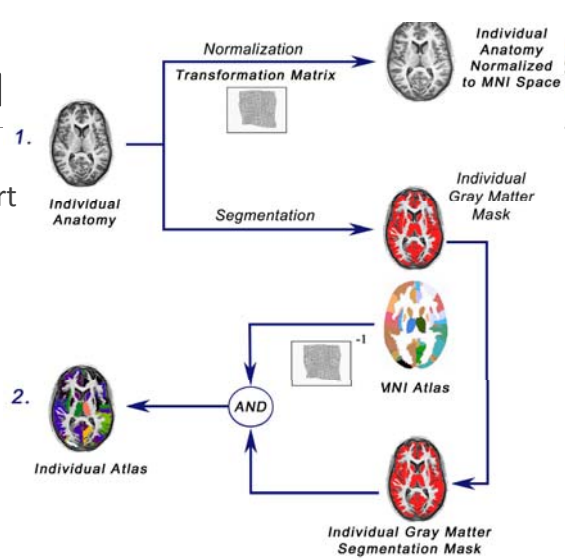
/Atlased/mwanat_Atlas.img





IBASPM

Individual atlas flowchart



IBASPM debug

1. Remove REST path
2. fileparts error

>> open spm_write_sn.m

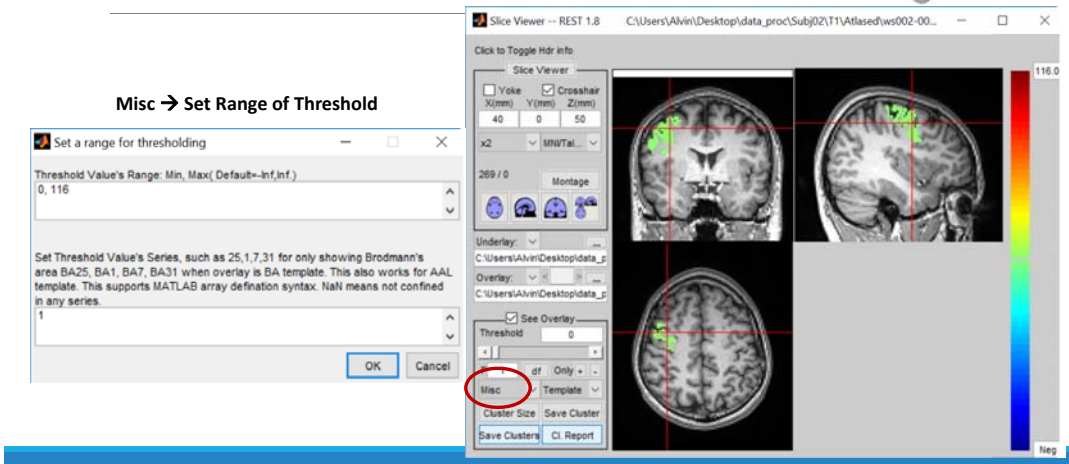
>> delete the forth output of **fileparts** (line 344 and 345)

```
342   %
343   function PO = prepend(PI,pre)
344   [pth,nm,xt] = fileparts(deblank(PI));
345   PO          = fullfile(pth,[pre nm xt]);
346   return;
347   %
```

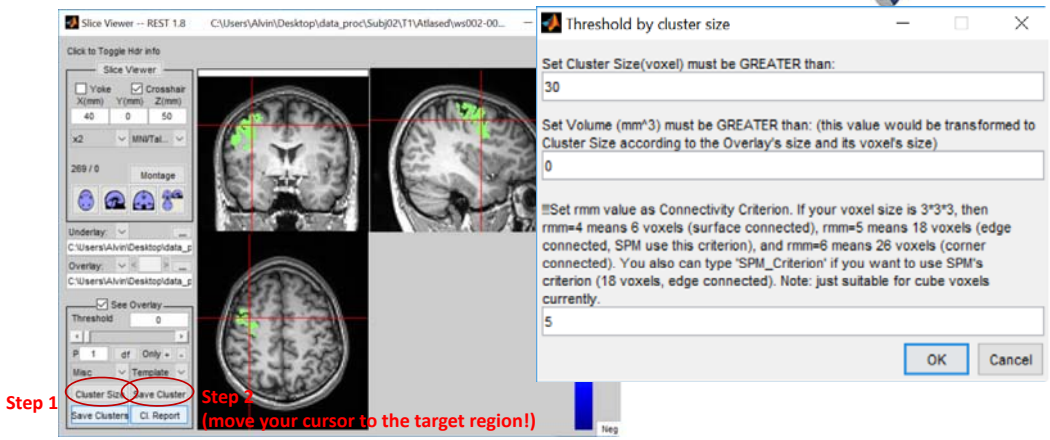

FunctCon

Atlas ROI

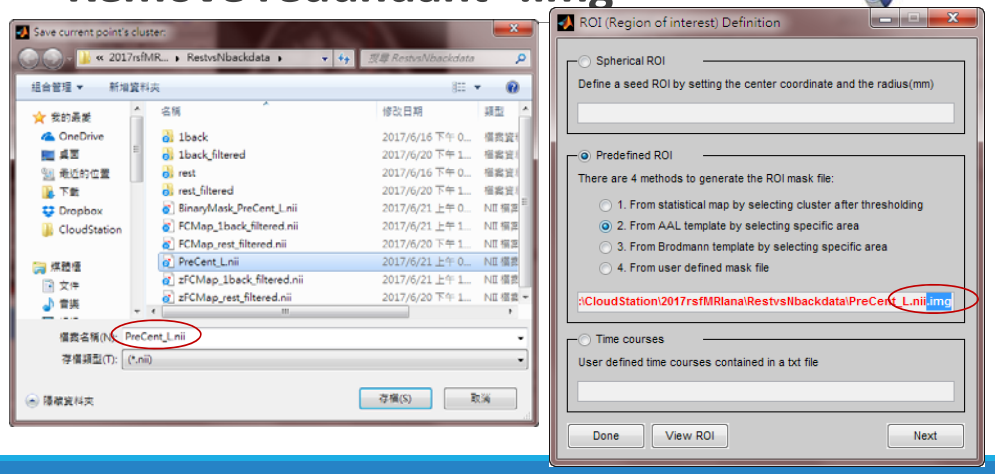
Misc → Set Range of Threshold



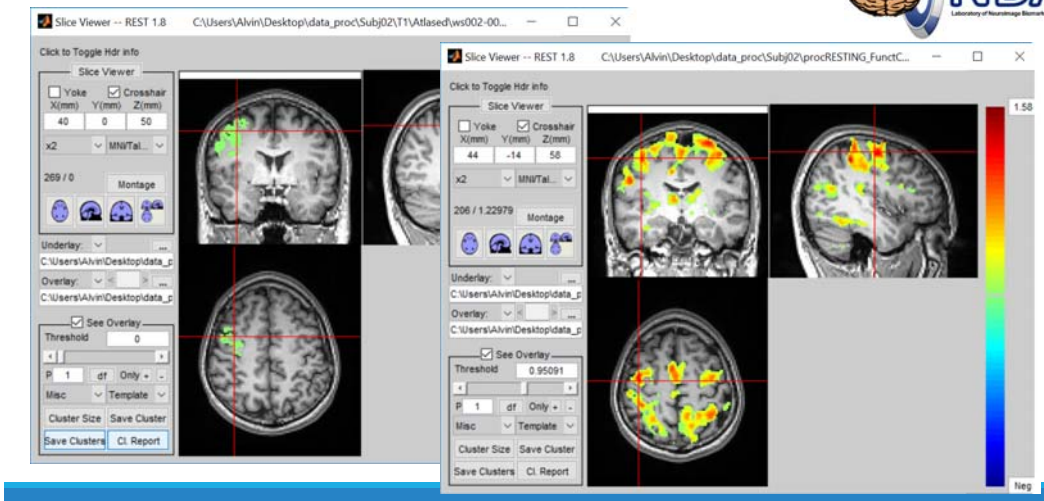
Create current cluster ROI mask



Remove redundant ".img"



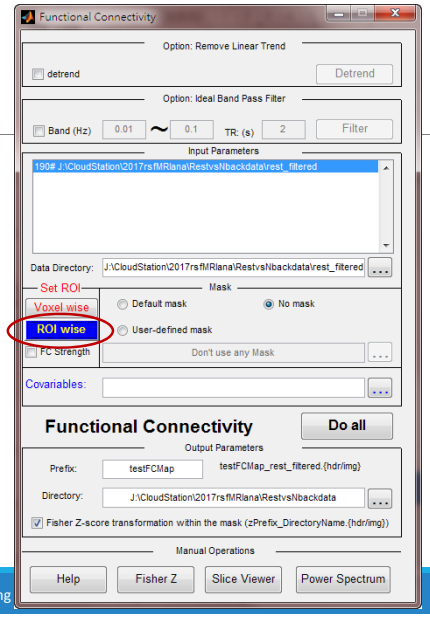
FunctCon Connectivity Maps

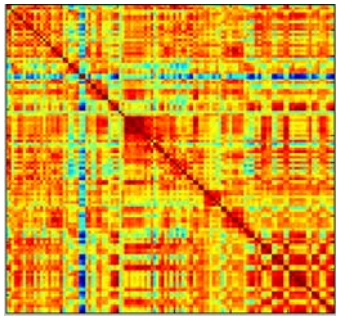


Atlas ROIs

Misc → Set Range of Threshold

Try it





Functional Connectivity logfile

FCMap_20160529_0601.log - Notepad

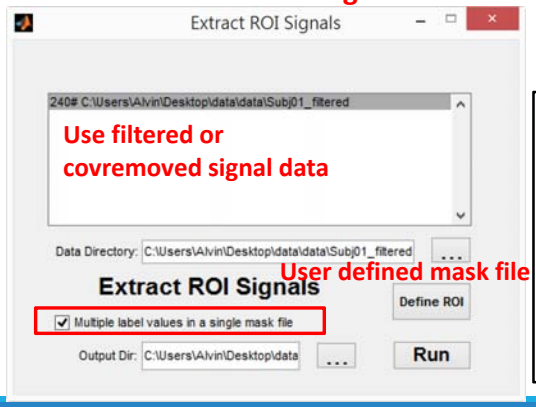
File Edit Format View Help

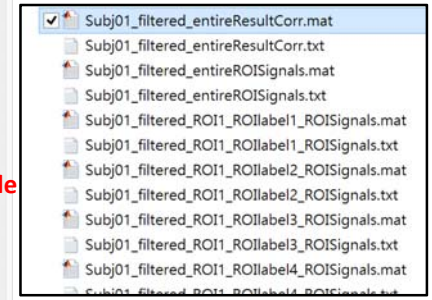
```
-----------------------------------------------------------------------
Functional Connectivity input parameters:
        Input Data Directories( ):
        ---------------------------------------------------------------
        240# C:\Users\Alvin\Desktop\data_proc\Subj02\ProcRESTING_filtered
        ---------------------------------------------------------------
        Mask file: C:\Users\Alvin\Desktop\data_proc\Subj02\Mask.nii
        Functional Connectivity Parameters
        ROI Definition:                 ROI Center(mm)=(-42, 0, 42); Radius=6.00 mm.
        ROI Definition:                 ROI Center(mm)=(-46, 10, 42); Radius=6.00 mm.
        ROI Definition:                 ROI Center(mm)=(-32, -28, 68); Radius=6.00 mm.
        ROI Definition:                 C:\Users\Alvin\Desktop\data_proc\Subj02\PreCent_R.nii
        Covariables Definition File:            C:\Users\Alvin\Desktop\data_proc\Subj02\RESTING\r
        Covariables Polort (Polynomial Orthogonal Degree):              0


-----------------------------------------------------------------------
Functional Connectivity output parameters:
```

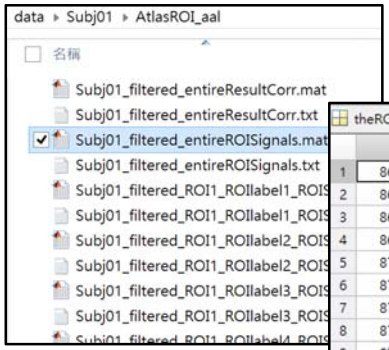

Extract Atlas ROI signals

Utilities → Extract ROI Signals





Extract Atlas ROI signals

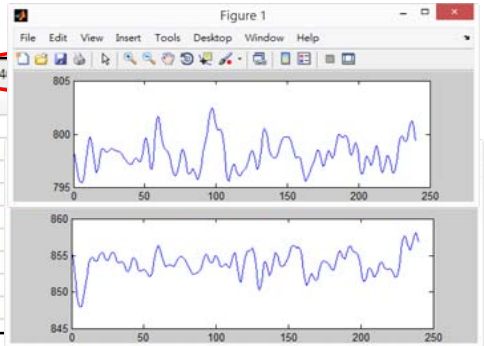


figure, plot(theROITimeCoursesTotal(:,2))

figure, plot(theROITimeCoursesTotal(:,4))

theROITimeCoursesTotal <24

	1	2
1	869.8929	798.1161
2	869.4746	797.0249
3	869.4209	796.2333
4	869.6546	795.7288
5	870.0611	795.4528
6	870.5762	795.4193
7	871.1823	795.7328
8	871.8634	796.4895
9	872.4967	797.6218
10	872.8458	798.8268



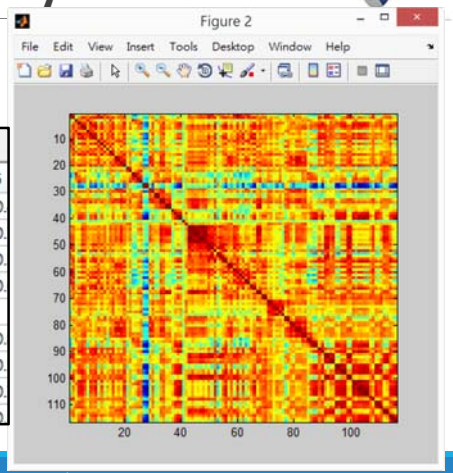
Correlation/Connectivity Matrix

load entireResultCorr.mat

figure, imagesc(ResultCorr)

ResultCorr <116x116 double>

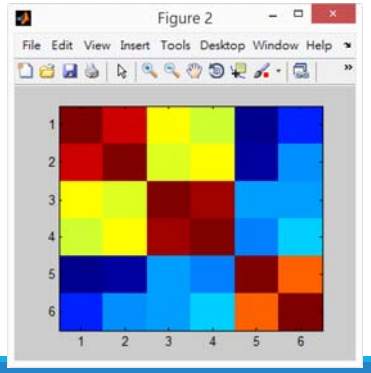
	1	2	3	4	5
1	1	0.8071	0.1583	0.2188	0.
2	0.8071	1	0.2747	0.5703	0.
3	0.1583	0.2747	1	0.6204	0.
4	0.2188	0.5703	0.6204	1	0.
5	0.4768	0.7410	0.5514	0.6922	
6	0.4577	0.7162	0.5147	0.7309	0.
7	0.5477	0.5605	0.7443	0.5227	0.
8	0.4411	0.7293	0.5922	0.9124	0.
9	0.5072	0.7304	0.4864	0.6655	0



Exercise

Extract AAL 23,24,35,36,61,62 ROI signals and correlation matrix.

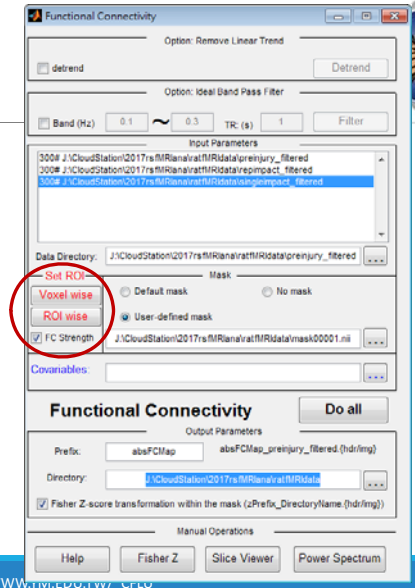
- Create a mask image with selected ROI labels
- Extract ROI signals
- Plot correlation/connectivity matrix



FC Strength Map

1. Add **fc_Lu_gui;** to line 518, and mark line 517 in **rest.m**

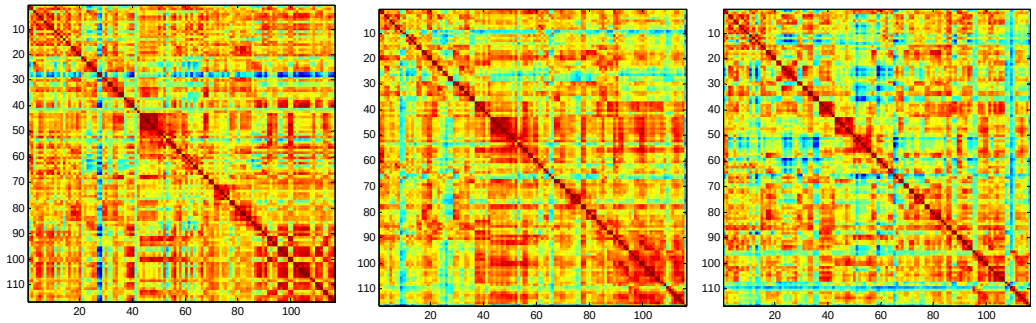
2. Copy **fc_Lu_gui.m**, **fc_Lu_gui.fig** and **fc_Lu.m** files to REST_V1.8_130615 folder.



Statistics on Connectivity Matrices

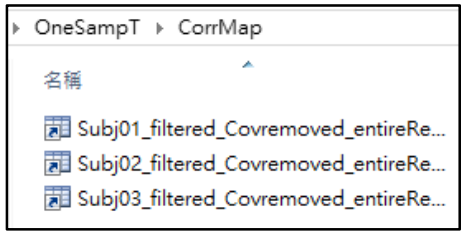
Descriptive statistics, one-sample t-test, two-sample t-test, paired t-test,….

Subj01 **Subj02** **Subj03**



Perform ttest on Correlation Maps

Put all Correlation Maps file in a “CorrMap” directory




```
clear all

dirname='.\CorrMap';
dirinfo=dir(dirname);
dirinfo(1:2)=[];

CorrMapall=[];
for i=1:length(dirinfo)
    load([dirname '\' dirinfo(i).name])
    CorrMapall(:,:,i)=ResultCorr;
end
figure,imagesc(mean(CorrMapall,3))
```

Perform ttest on Correlation Maps

```
pMap=zeros(size(CorrMapall,1),size(CorrMapall,2));
hMap=zeros(size(CorrMapall,1),size(CorrMapall,2));
for i=1:size(CorrMapall,1)
    for j=i+1:size(CorrMapall,2)
        tmp=squeeze(CorrMapall(i,j,:));
        tmp(isnan(tmp))=[];
        [hMap(i,j),pMap(i,j)]=ttest(tmp,0);  % one-sample
    end
end

%% hint for two-sample t-test, and paired t test
%       [hMap(i,j),pMap(i,j)]=ttest2(tmp1,tmp2,0);  % two-sample
%       [hMap(i,j),pMap(i,j)]=ttest(tmp1,tmp2,0);  % paired ttest
```

Correct “nanvar_base” error in ttest.m

```
df = max(samplesize - 1,0);
xmean = nanmean(x,dim);
% sdpop = nanstd(x,[],dim);  % by
sdpop = std(x,[],dim);
ser = sdpop ./ sqrt(samplesize);
tval = (xmean - m) ./ ser;
```


Q & A