Introduction

This manual is edited to help researchers interested in using magnetic resonance imaging (MRI) data in MEG source modeling. We will specifically use the following software packages.

I. FreeSurfer
   An open source software suite for processing and analyzing (human) brain MRI images. For more information, please check
   https://surfer.nmr.mgh.harvard.edu/

fMRI data pre-processing basically involves the following steps:

- Unpack DICOM files into the file format allowing us for subsequent processing
- Motion correction
- Slice-timing correction
- Spatial smoothing

Environment setup

- **Login**

1. Open a SSH session
2. Login to server

```
%ssh 140.119.165.24 -l username[1] -Y

(%ssh -o TCPKeepAlive=no -o ServerAliveInterval=15
140.119.165.24 -l username –Y)
```

3. Goto your working directory[2]

```
> cd
/space/maki5/1/users/fhlin/ini_vm_nccu/10102012_ChangCI/epi
_data
```

4. Prepare environment

```
> source /space/maki/1/pubsw/bme-dev-env-dev.csh
```

[1] Here I use "user_name" as the example.

[2] Here the working directory is `/space/maki5/1/users/fhlin/ini_vm_nccu/10102012_ChangCI/epi_data`. You should change that accordingly in your own analysis.

Unpack DICOM files

- ### Scan EPI sessions

  The first step is to check how many EPI "sessions" in the data stored in the folder `VM_EPI`.

  ```
  > unpacksdcmdir -src VM_EPI -targ . -scanonly ./info
  ```

  By the end of screen output, you may find the following:

  ```
  Done scanning Wed Feb 19 16:47:01 CST 2014
  ------------------------------------------
    4         ep2d_bold_MGH  ok   64  64  30 120
  10102012_CHANGCI.MR.FHLIN_FMRI.0004.0001.2012.10.10.19.21.1
  1.750000.5743858.IMA
  ```

  It indicates there is only ONE (1) session in this data. And the EPI session has session number 4.

- ### Perform unpacking

  Now ONE (1) file is needed to specify which run(s) is going to be unpacked. Here I created a file called unpack.rule. The content of the file is:

  ```
  > cat unpack.rule
  4    bold nii  f.nii
  ```

  It specifies that run 4 should be unpacked inside the folder BOLD with nii[3] file format. The output file should be bold/004/f.nii.

  Now perform the unpacking with this configuration rile.

  ```
  > unpacksdcmdir -src VM_EPI -targ . -cfg ./unpack.rule
  ```

  If things run smoothly, you would see the last few lines of your screen showing this:

  ```
  StartTime: Wed Feb 19 16:51:22 CST 2014
  EndTime:   Wed Feb 19 16:51:35 CST 2014
  unpacksdcmdir Done
  ```

  Double-check if files are there as expected:

[3] Nii is the file name extension for the NifTI file format, a common file format storing neuroimaging data. Please see http://nifti.nimh.nih.gov/nifti-1/ for details.

```
> ls –al bold/004
total 78424
drwxrwxr-x 2 fhlin fhlin     4096 Apr 24  2014 .
drwxrwxr-x 3 fhlin fhlin     4096 Feb 19 16:56 ..
-rw-rw-r-- 1 fhlin fhlin     9600 Apr 24  2014 flf
-rw-rw-r-- 1 fhlin fhlin 29491552 Apr 24  2014 f.nii
-rw-rw-r-- 1 fhlin fhlin    69458 Apr 24  2014 f.nii-
infodump.dat
```

It specifies that run 4 should be unpacked inside the folder BOLD with nii file format. The output file should be bold/004/f.nii.

Pre-processing steps

Two files are needed to specify all folders containing unpacked EPI data. Here I created `sessid` and `sessdir` two texts files for this purpose:

```
>pwd
/autofs/space/maki5_001/users/fhlin/ini_vm_nccu/10102012_Ch
angCI/epi_data

> ls
rolle7:/space/maki5/1/users/fhlin/ini_vm_nccu/10102012_Chan
gCI/epi_data> ls -al
total 120
drwxr-xr-x  5 fhlin fhlin  4096 Apr 24 17:52 .
drwxr-xr-x 11 fhlin fhlin  4096 Apr 24 17:50 ..
drwxrwxr-x  3 fhlin fhlin  4096 Feb 19 16:56 bold
-rw-rw-r--  1 fhlin fhlin 18000 Apr 24 17:52
dicomdir.sumfile
-rw-rw-r--  1 fhlin fhlin   126 Feb 19 16:47 info
drwxrwxr-x  2 fhlin fhlin  4096 Feb 19 21:49 log
-rw-rw-r--  1 fhlin fhlin    56 Feb 19 16:33 sessdir
-rw-rw-r--  1 fhlin fhlin     9 Feb 19 16:33 sessid
-rw-rw-r--  1 fhlin fhlin     0 Feb 19 21:47 stc-session
-rw-rw-r--  1 fhlin fhlin 50544 Apr 24 17:52 unpack.log
-rw-rw-r--  1 fhlin fhlin    17 Feb 19 16:49 unpack.rule
drwxr-xr-x  2 fhlin fhlin 16384 Dec  4 01:52 VM_EPI

>cat sessid
epi_data

>cat sessdir
/space/maki5/1/users/fhlin/ini_vm_nccu/10102012_ChangCI
```

- **Make analysis/pre-processing template**

```
> mktemplate-sess -sf sessid -df sessdir
```

- **Motion correction**

All files inside each folder within 'bold' will be motion corrected.

```
> mc-sess -sf sessid -df sessdir -per-run
```

Check the output files:

```
>ls –l bold/004
total 79904
-rw-rw-r-- 1 fhlin fhlin     9600 Apr 24 17:52 flf
-rw-rw-r-- 1 fhlin fhlin    20210 Apr 24  2014
fmcpr.mat.aff12.1D
-rw-rw-r-- 1 fhlin fhlin    11040 Apr 24 17:54 fmcpr.mcdat
-rw-rw-r-- 1 fhlin fhlin 52054603 Apr 24  2014 fmcpr.nii.gz
-rw-rw-r-- 1 fhlin fhlin     5362 Apr 24  2014
fmcpr.nii.gz.mclog
-rw-rw-r-- 1 fhlin fhlin 29491552 Apr 24 17:52 f.nii
-rw-rw-r-- 1 fhlin fhlin    69458 Apr 24 17:52 f.nii-
infodump.dat
-rw-rw-r-- 1 fhlin fhlin      470 Apr 24  2014
mcdat2extreg.log
-rw-rw-r-- 1 fhlin fhlin     6480 Apr 24  2014 mcprextreg
-rw-rw-r-- 1 fhlin fhlin       21 Apr 24  2014 template.log
-rw-rw-r-- 1 fhlin fhlin   119787 Apr 24  2014
template.nii.gz
drwxrwxr-x 3 fhlin fhlin     4096 Apr 24  2014
tmpdir.mcdat2extreg.31315
drwxrwxr-x 3 fhlin fhlin     4096 Apr 24  2014
tmpdir.mcdat2extreg.31428
```

The file `fmcpr.nii.gz` contains the motion-corrected EPI data in zipped nii format.

- **Slice timing correction**

Slice timing correction is going to apply to files with file stem 'fmcpr'. The output file after slice timing correction has the file stem 'fmcprstc'.

```
> stc-sess –sf sessid –df sessdir–i fmcpr –o fmcprstc
```

Check the output files:

```
> ls –l bold/004
total 131328
-rw-rw-r-- 1 fhlin fhlin     9600 Apr 24 17:52 flf
-rw-rw-r-- 1 fhlin fhlin    20210 Apr 24 17:56
fmcpr.mat.aff12.1D
-rw-rw-r-- 1 fhlin fhlin    11040 Apr 24 17:54 fmcpr.mcdat
-rw-rw-r-- 1 fhlin fhlin 52054603 Apr 24 17:56 fmcpr.nii.gz
-rw-rw-r-- 1 fhlin fhlin     5362 Apr 24 17:56
fmcpr.nii.gz.mclog
```

```
-rw-rw-r-- 1 fhlin fhlin 52653539 Apr 24  2014
fmcprstc.nii.gz
-rw-rw-r-- 1 fhlin fhlin     3211 Apr 24  2014
fmcprstc.nii.gz.log
-rw-rw-r-- 1 fhlin fhlin 29491552 Apr 24 17:52 f.nii
-rw-rw-r-- 1 fhlin fhlin    69458 Apr 24 17:52 f.nii-
infodump.dat
-rw-rw-r-- 1 fhlin fhlin      470 Apr 24 17:56
mcdat2extreg.log
-rw-rw-r-- 1 fhlin fhlin     6480 Apr 24 17:56 mcprextreg
-rw-rw-r-- 1 fhlin fhlin       21 Apr 24 17:55 template.log
-rw-rw-r-- 1 fhlin fhlin   119787 Apr 24 17:55
template.nii.gz
drwxrwxr-x 3 fhlin fhlin     4096 Apr 24 17:55
tmpdir.mcdat2extreg.31315
drwxrwxr-x 3 fhlin fhlin     4096 Apr 24 17:55
tmpdir.mcdat2extreg.31428
```

The file `fmcprstc.nii.gz` contains the motion-corrected AND slice timing corrected EPI data in zipped nii format.

- **Spatial smoothing**

Spatial smoothing is going to apply to files with file stem 'fmcprstc' using a Gaussian smooth kernel with full-width-half-maximum (FWHM) of 10 mm. The output file after slice timing correction has the file stem 'fmcprstcs'.

```
> spatialsmooth-sess -sf sessid -df sessdir -i fmcprstc -o
fmcprstcs -fwhm 10 -outfmt nii -no-mask
```

Check the output files:

```
> ls –l bold/004
total 188932
-rw-rw-r-- 1 fhlin fhlin     9600 Apr 24 17:52 flf
-rw-rw-r-- 1 fhlin fhlin    20210 Apr 24 17:56
fmcpr.mat.aff12.1D
-rw-rw-r-- 1 fhlin fhlin    11040 Apr 24 17:54 fmcpr.mcdat
-rw-rw-r-- 1 fhlin fhlin 52054603 Apr 24 17:56 fmcpr.nii.gz
-rw-rw-r-- 1 fhlin fhlin     5362 Apr 24 17:56
fmcpr.nii.gz.mclog
-rw-rw-r-- 1 fhlin fhlin 52653539 Apr 24  2014
fmcprstc.nii.gz
-rw-rw-r-- 1 fhlin fhlin     3211 Apr 24  2014
fmcprstc.nii.gz.log
-rw-rw-r-- 1 fhlin fhlin 58982752 Apr 24  2014
fmcprstcs.nii
```

```
-rw-rw-r-- 1 fhlin fhlin 29491552 Apr 24 17:52 f.nii
-rw-rw-r-- 1 fhlin fhlin    69458 Apr 24 17:52 f.nii-
infodump.dat
-rw-rw-r-- 1 fhlin fhlin      470 Apr 24 17:56
mcdat2extreg.log
-rw-rw-r-- 1 fhlin fhlin     6480 Apr 24 17:56 mcprextreg
-rw-rw-r-- 1 fhlin fhlin       21 Apr 24 17:55 template.log
-rw-rw-r-- 1 fhlin fhlin   119787 Apr 24 17:55
template.nii.gz
drwxrwxr-x 3 fhlin fhlin     4096 Apr 24 17:55
tmpdir.mcdat2extreg.31315
drwxrwxr-x 3 fhlin fhlin     4096 Apr 24 17:55
tmpdir.mcdat2extreg.31428
```

The file `fmcprstc.nii` contains the motion-corrected, slice timing corrected, AND spatially smoothed EPI data in nii format.