

Introduction

This manual is edited to help researchers interested in reconstructing inverse imaging (InI) data acquired from Siemens MRI scanner. 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/>

InI reconstruction basically involves the following steps:

- Convert raw data (meas_XXXXX_.dat format in Siemens)
- Convert the reference scan into a 3D sum-of-squares image volume
- Co-register between the SoS image volume from the reference scan and the anatomical information reconstructed by FreeSurfer
- Reconstruct InI accelerated scan time point-by-time point

Environment setup

- **Login**

1. Open a SSH session
2. Login to server

```
%ssh 140.119.165.24 -l username1 -Y
```

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

3. Goto your working directory²

```
> 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.

Convert raw data

- **Convert raw data from a Skyra scanner**

The first step is to convert the raw data (meas_XXXX_.dat files) into a format that can be easily processed by Matlab. Here we assume that the raw data file to be converted is name 'meas.dat', which can be created by making an alias or actually renaming the file. For a Skyra scanner using IDEA version VD11, you can try the following commands in Matlab:

```
% converting an InI reference scan

ice_master_vd11('nav_data_fraction',0.1,'file_raw','meas.dat',
'flag_phase_cor_algorithm_lsq',1,'flag_regrid',1,'flag_phase_cor_jbm',1,'flag_3d',1);

% converting an InI accelerated InI scan

ice_master_vd11('nav_data_fraction',0.1,'file_raw','meas.dat',
'flag_phase_cor_algorithm_lsq',1,'flag_regrid',1,'flag_phase_cor_jbm',1,'flag_output_burst',1,'n_measurement',3800,
'flag_rev_even_odd',1);
```

Note that here the number of time points (measurements, 3800) was clearly specified in order to reduce the processing time (by minimizing the file I/O).

- **Convert raw data from a Tim Trio scanner**

For a Tim Trio scanner using IDEA version VB17, you can try the following commands in Matlab:

```
% converting an InI reference scan

ice_master('flag_vb15',1,'nav_data_fraction',0.1,'file_raw','meas.dat',
'flag_phase_cor_algorithm_lsq',1,'flag_regrid',1,'flag_phase_cor_jbm',1,'flag_3d',1);

% converting an InI accelerated InI scan

ice_master('flag_vb15',1,'nav_data_fraction',0.1,'file_raw','meas.dat',
'flag_phase_cor_algorithm_lsq',1,'flag_regrid',1,'flag_phase_cor_jbm',1,'flag_output_burst',1,'n_measurement',2400,
'flag_rev_even_odd',1);
```

Note that here the number of time points (measurements, 2400) was clearly specified in order to reduce the processing time (by minimizing the file I/O).

Also, even though the IDEA was version VB 17, we still use the flag for VB 15. This is because the header information was the same between two versions in the InI sequence.

Convert raw data

- **InI reference scan with the partition encoding direction in the anterior-posterior direction (accelerated InI images are thick coronal slices)**

The second step is to convert all channels of a reference scan to a sum-of-squares (SoS) image volume for subsequent co-registration. To do this, you can use the following command in the template file `ini_make_ref_gre3d_01.m`.

Importantly, this command will read all the bfloat files, each of which corresponds to one slice from one channel of either real or imaginary part of the image from a file specified by the variable 'ref_dir':

```
close all; clear all;
```

```
ref_dir='../meas/ref_01';
```

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
pdir=pwd;
```

```
fprintf('reading data from [%s]...\n',ref_dir);
cd(ref_dir);
[d0,d1]=ice_show;
.....
...
```

So this variable 'ref_dir' should be changed according to where you store the reference scan images data.

Then it calculates the SoS image volume. This SoS image volume will be saved as 'gre.mgh' in the directory specified by 'ref_dir'.

At the local working directory, an Matlab data file 'ref_data_3d_gre3d_01.mat' will be saved with the variable 'ref_data', which is a 4D data structure including the reference data of [x, y, z, channel].

Lastly, a Matlab file 'mask.mat' will be created with a variable 'mask', which is a 3D image volume mask showing the head.

- **InI reference scan with the partition encoding direction in the left-right direction (accelerated InI images are thick sagittal slices)**

If you used the left-right direction as the partition encoding direction in your InI (reference/accelerated) scan, you should use the following template file in order to get correct image orientation.

`ini_make_ref_gre3d_sag_01.m.`

Co-register between the SoS image volume from the reference scan and the anatomical information reconstructed by FreeSurfer

We then need to register the SoS image volume from the reference scan to the anatomical brain reconstructed by FreeSurfer. Here you must have your FreeSurfer brain reconstructed first. The co-registration can be easily done by using `flirt` in the FSL package included in FreeSurfer.

```
fslregister --s ChenCK --mov ../meas/ref_01/gre.mgh --reg  
./register1.dat --maxangle 70 --initxfm
```

Here the subject 'ChenCK' was selected as the target subject. You should have the FreeSurfer environment variable `$SUBJECTS_DIR` setup correctly to include the target subject's reconstructed brain surfaces.

This script will read the SoS image from the InI reference scan stored at a relative location `../meas/ref_01/gre.mgh`. You may have to double check this.

The output of this co-registration is a file named 'register1.dat', which includes the image volume voxels size and 12 parameters for rigid-body transformation.

Reconstruct InI accelerated scan time point-by-time point

Use the template file `ini_npc_volrecon_01.m` to reconstruct InI data at each time point. At the beginning of this file, you may have to modify some variables.

```
close all; clear all;

file_ref='ref_data_3d_gre3d_01.mat';
data_dir={
    '../meas/ini_01';
};

file_mgh_template='../meas/ref_01/gre.mgh';

file_register='register1.dat';
bad_channel=[];

n_dummy=1;
n_ini=64;
...
...
%morphing to the target subject
flag_morph=1;
target_subject='fsaverage';
subject='ChenCK';
...
...
```

Clearly you need to correctly specify the InI reference scan file processed previously and the path to the data including the accelerated InI measurements. You may include more than one run of the data by appending the content of the variable `'data_dir'`. The variable `'file_mgh_template'` is used as a file template to create the InI reconstruction output. In this case, a file in `.mgh` format will be created to include the reconstructed InI brains using a 4D structure of `[x, y, z, time]`. The variable `'file_register'` includes the registration file created before to co-register between the SoS image volume in the reference scan and the FreeSurfer reconstructed brain.

If the `flag_morph` was set to 1, it means that each reconstructed InI brain will be morphed to the surface of the selected target subject specified by the variable `'target_subject'`. Here we used the template subject `'fsaverage'` provided by FreeSurfer as the target subject. To enable morphing, you also need to specify the source subject, which was set to `'ChenCK'` in this example. Naturally both the target subject and the source subject should have FreeSurfer reconstruction files included in the environment variable `$SUBJECTS_DIR`.


```
rolle8:/space/maki5/1/users/fhlin/ini_7t/res_3t_20141107_S001_Chih-  
Kang_Chen/analysis> ls -al *.stc  
-rw-rw-r-- 1 fhlin fhlin 98282248 Nov 14 22:25 ChenCK_2_fsaverage_ini_01_npc__mne-  
lh.stc  
-rw-rw-r-- 1 fhlin fhlin 98282248 Nov 14 22:28 ChenCK_2_fsaverage_ini_01_npc__mne-  
rh.stc  
-rw-rw-r-- 1 fhlin fhlin 1415193616 Nov 14 22:22 ini_01_npc__mne-lh.stc  
-rw-rw-r-- 1 fhlin fhlin 1384905616 Nov 14 22:23 ini_01_npc__mne-rh.stc
```

If things work smoothly, files listed above will be created, including the STC files of each InI reconstruction morphed to the target subject 'fsaverage' (ChenCK_2_fsaverage_ini_01_npc__mne-?h.stc). Also the STC files of each InI reconstruction before morphing will be created, too (ini_01_npc__mne-?h.stc).