Electrode Localization Toolbox Manual

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Department of Neurology, New York University School of Medicine

for questions, please email Hugh Wang (Xiuyuan.Wang at nyumc.org)

Attention:

1. **The Electrode Localization Toolbox was tested and only runs under 64bit Lunix**
2. **Preferred software version (or above): Matlab R2009a, SPM5, FSL 4.1.9, and FREESURFER 5.0.0**
3. **Please add SPM and ntools_elec folder into Matlab path**
4. **Please install FSL and FREESURFER properly**

Autocoregistration

Autocoregistration is a program that coregisters the post-implantation image with the pre-implantation image using fsl commands to coregister, match to standard MNI images, and skull strip. Input can be both .nii and .mgz files. It also using Freesurfer subject aseg file to remove the cerebellum so that it will give a clear view for the electrodes on inferior temporal lobe with 3D rendering in MRIcro.

Run ntools_elec_autocoreg In MATLAB command window. In the pop-ups:

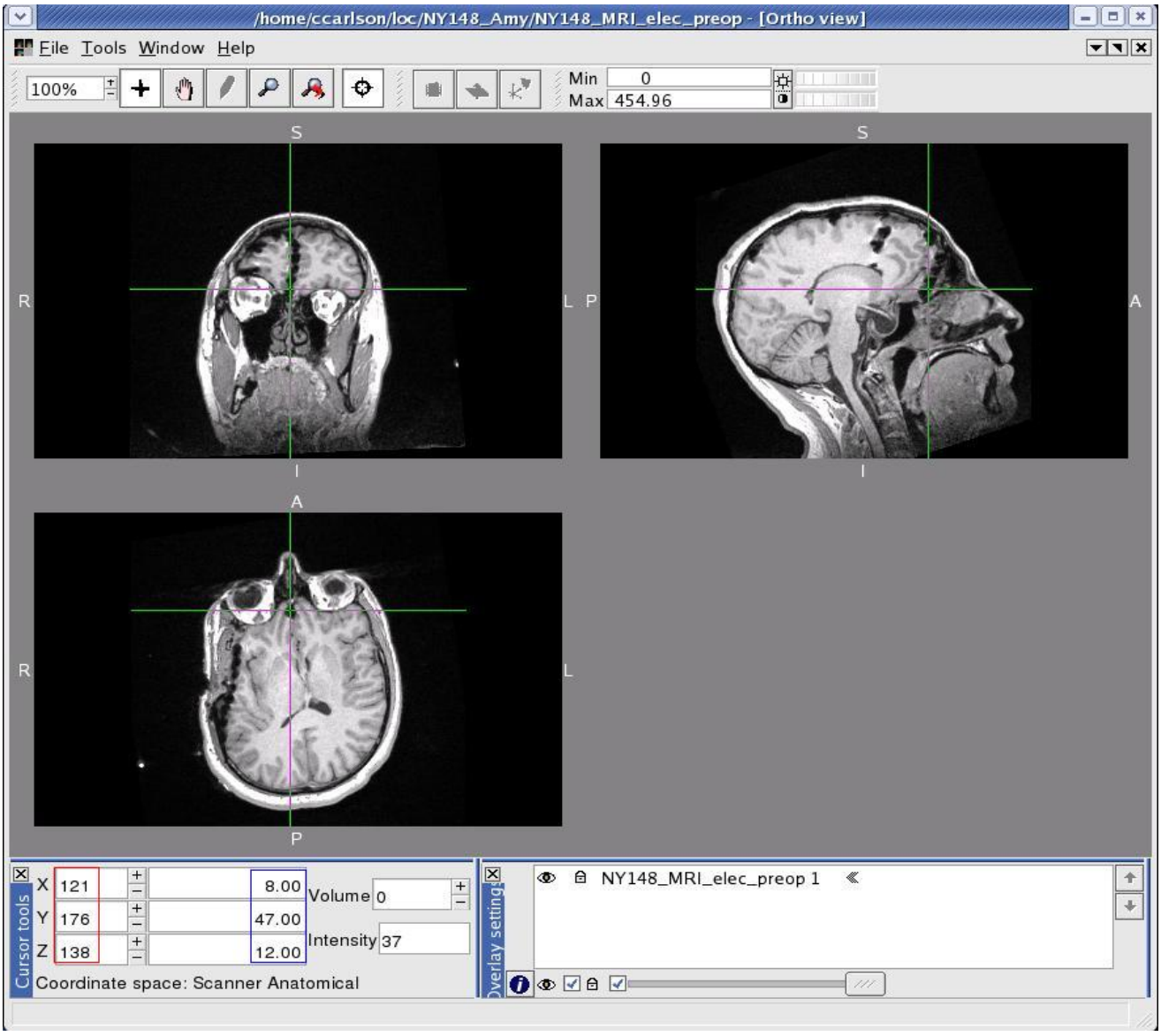
Select Freesurfer T1.mgz
Select $SUBJECTS_DIR/subject/mri/T1.mgz
Select $SUBJECTS_DIR/subject/mri/aseg.mgz
Select elec_MRI.nii.gz

This program takes a few minutes. A elec_preop.nii.gz file should be written, as well as elec_preop.mat, elec_preop_brain.nii.gz, elec_preop_brain_cortex.nii.gz, T1.nii.gz.

Electrode Localization

Electrode localization is composed of two parts: manual localization of some of the electrodes and automated projection of the rest of the electrodes.

Manual localization

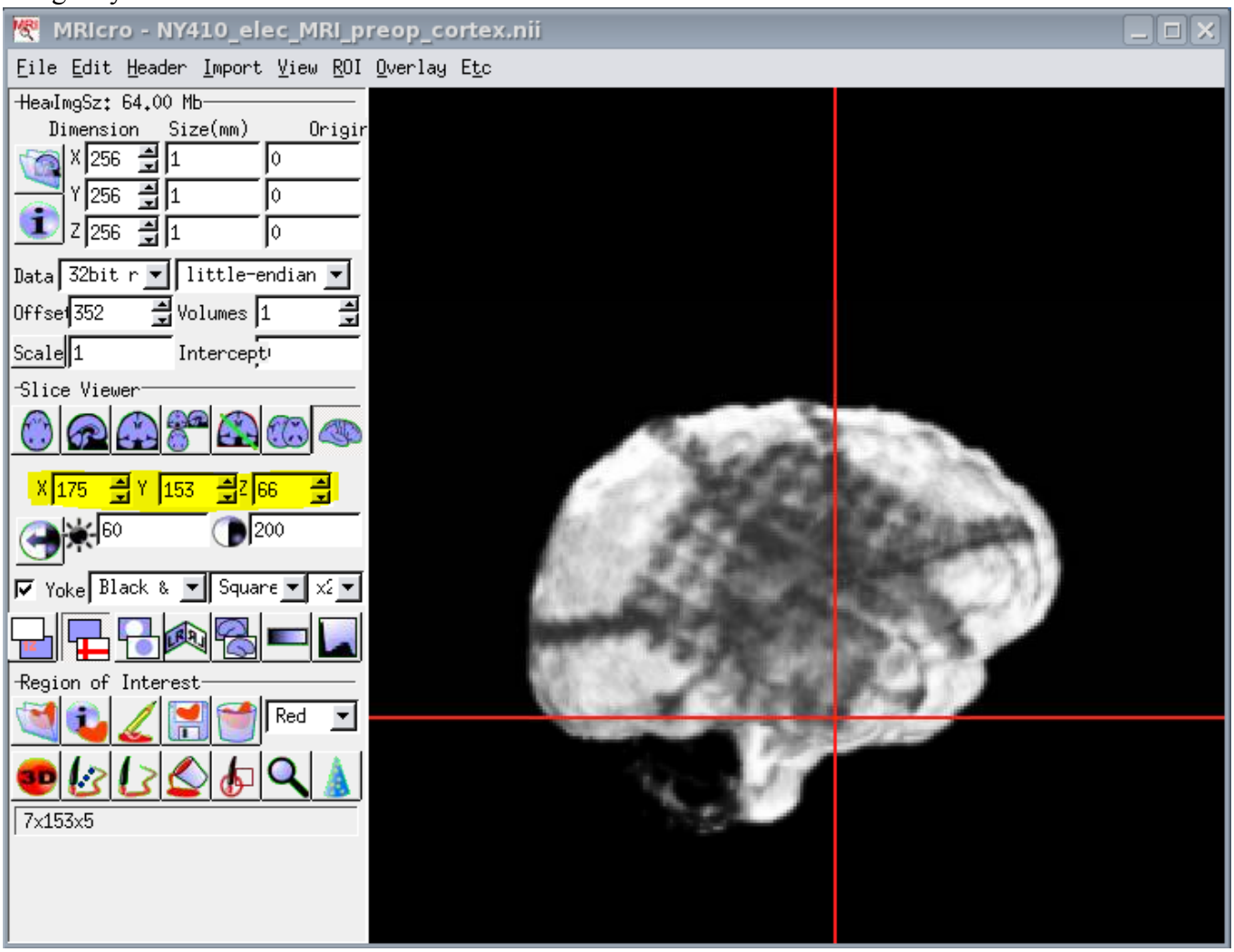


Initial electrodes RAS coordinates are given from FSLVIEW. Use the crosshair to find the center of the electrode (best approximation) and enter the coordinates found in blue box in above picture into the initial electrodes coordinates text file.

So the idea here is to localize the following:

1. Depths: the first and last electrode
2. Strips: every electrode
3. Grid: any 2 or 3 electrodes in the grid. Usually aim for corner electrodes. If the edges of grid are clear on coregistered mri, it is always preferred to select all 4 corner electrodes either clockwise or anticlockwise. *Attention: If there are 2 grids labeled with the same letter, or one grid broken up into several parts, treat them as separate grids and label them differently, for example, GB and GC, adjusting the numbering of the rest grids. After a final image is created, enter the output electrodes coordinates text file, and manually adjust each point to its original label on the powerpoint. For example, everything labeled Grid C with adjusted numbering will be changed back to GB# (# = original number on GB).

It'll be helpful to have MRIcro opening the elec_preop_brain_cortex.nii.gz (generated from autocoregistration) with 3D rendering to give a general view of how the electrodes spatially distributed. However MRIcro only shows the voxel coordinates (highlighted in the picture below), which corresponds to the numbers in red box. You can select an electrode from MRIcro and type the coordinates into the red box column of FSLVIEW, that will give you the RAS coordinates in blue box.



An example of initial electrodes coordinates text:

	A	B	C	D	E
1	GB64	15	-73	33	G
2	GB8	32	-91	-29	G
3	GB1	68	-32	-38	G
4	GA25	40	40	-17	G
5	GA32	64	-7	5	G
6	GA8	70	-18	-26	G
7	GC8	62	-7	14	G
8	GC32	49	1	40	G
9	GC25	41	59	24	G
10	DA1	27	28	-38	D
11	DA8	51	4	-26	D
12	DP1	24	8	-16	D
13	DP8	52	-16	-20	D
14	DH1	-2	-24	-2	D
15	DH8	25	-45	-10	D
16	MC8	23	10	55	S
17	MC7	18	19	58	S
18	MC6	12	28	58	S
19	MC5	7	36	59	S
20	MC4	2	43	59	S
21	MC3	-2	52	53	S
22	MC2	-5	60	45	S
23	MC1	-5	66	39	S
24	MP1	-6	-16	26	S
25	MP2	-4	-25	31	S
26	MP3	-2	-33	35	S
27	MP4	-2	-43	38	S
28	MP5	-2	-51	43	S
29	MP6	5	-61	45	S
30	MO1	17	-51	-29	S
31	MO2	13	-59	-25	S
32	MO3	10	-66	-19	S
33	MO4	5	-74	-15	S
34	IO1	23	-43	-35	S
35	IO2	27	-52	-37	S
36	IO3	30	-60	-39	S
37	IO4	34	-69	-43	S

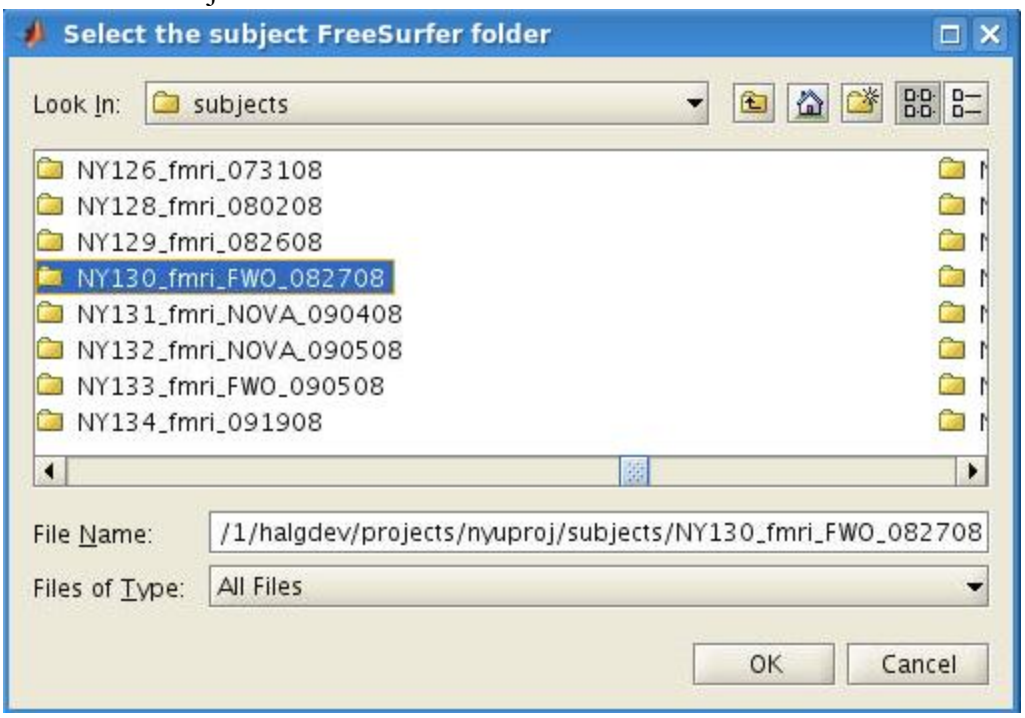
In the 5th column of the initial text file, indicate what type of the electrode it is (G for grid, D for depth and S for strip). *Attention: If you want to use 3 initial points for the grid, make sure these 3 points can shape a rectangular triangle, and the perpendicular foot has to be in the middle of the three.

Note:
The left coordinates are in voxels and the right coordinates are in millimeters.

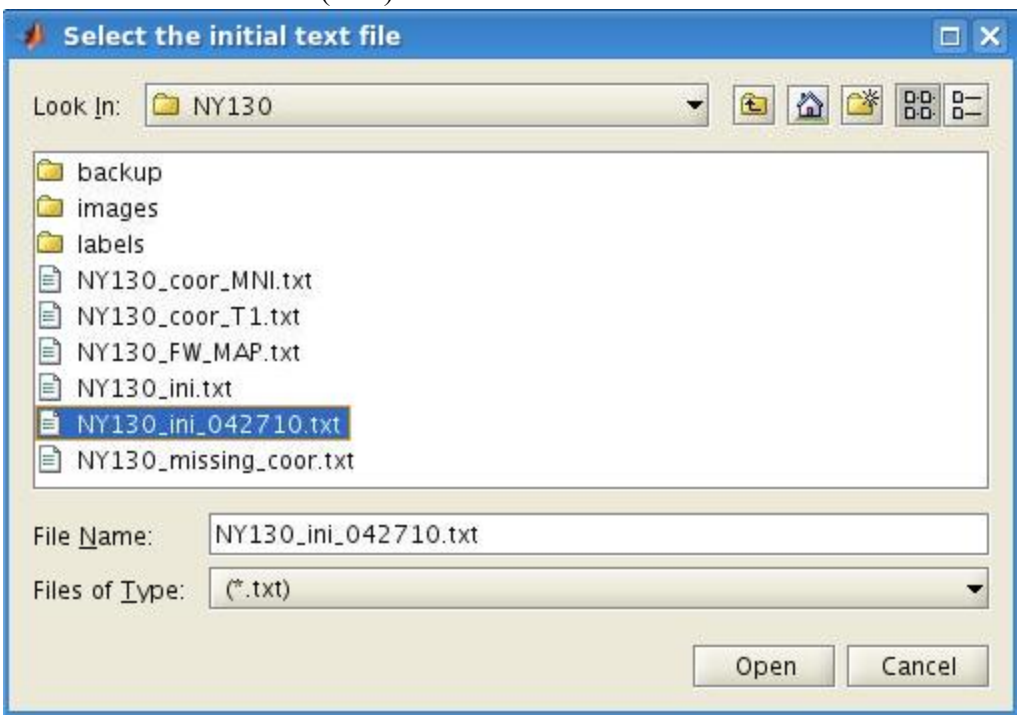
Automated Projection

Run ntools_elec in Matlab command window. In the pop-ups:

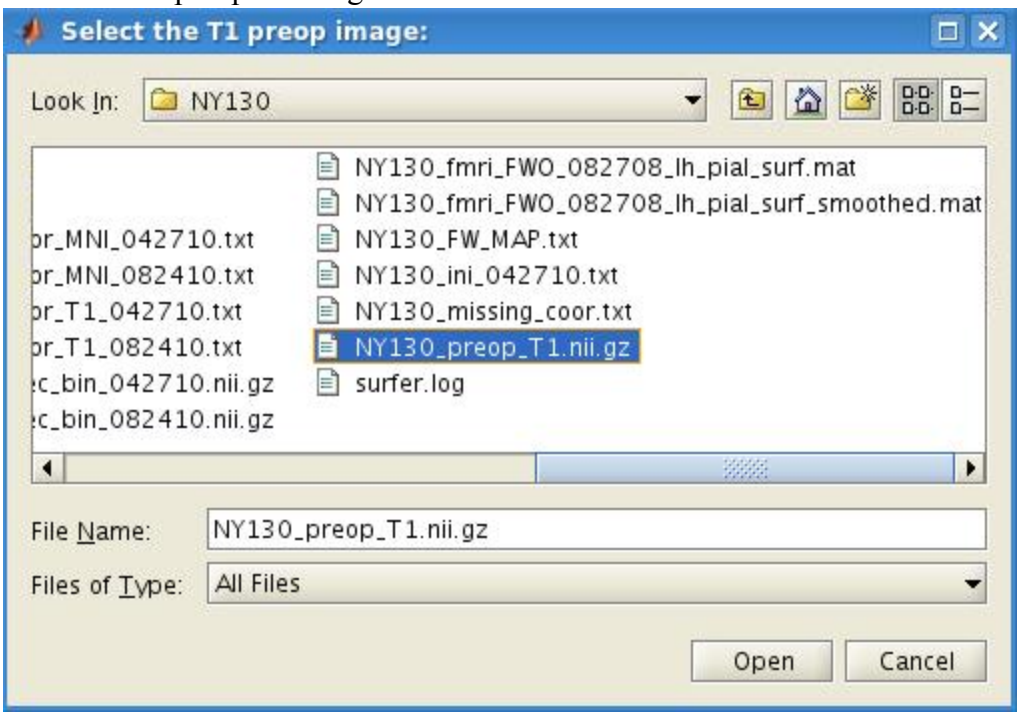
1. Select the subject's FREESURFERRECON folder



2. Select the ini.txt or xls(xlsx) file



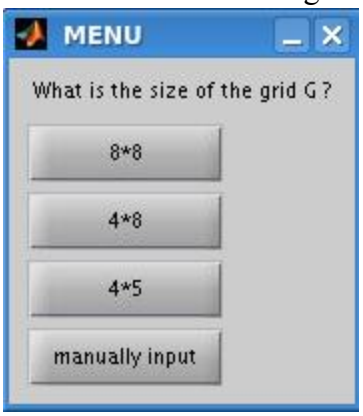
3. choose the preop T1 image:



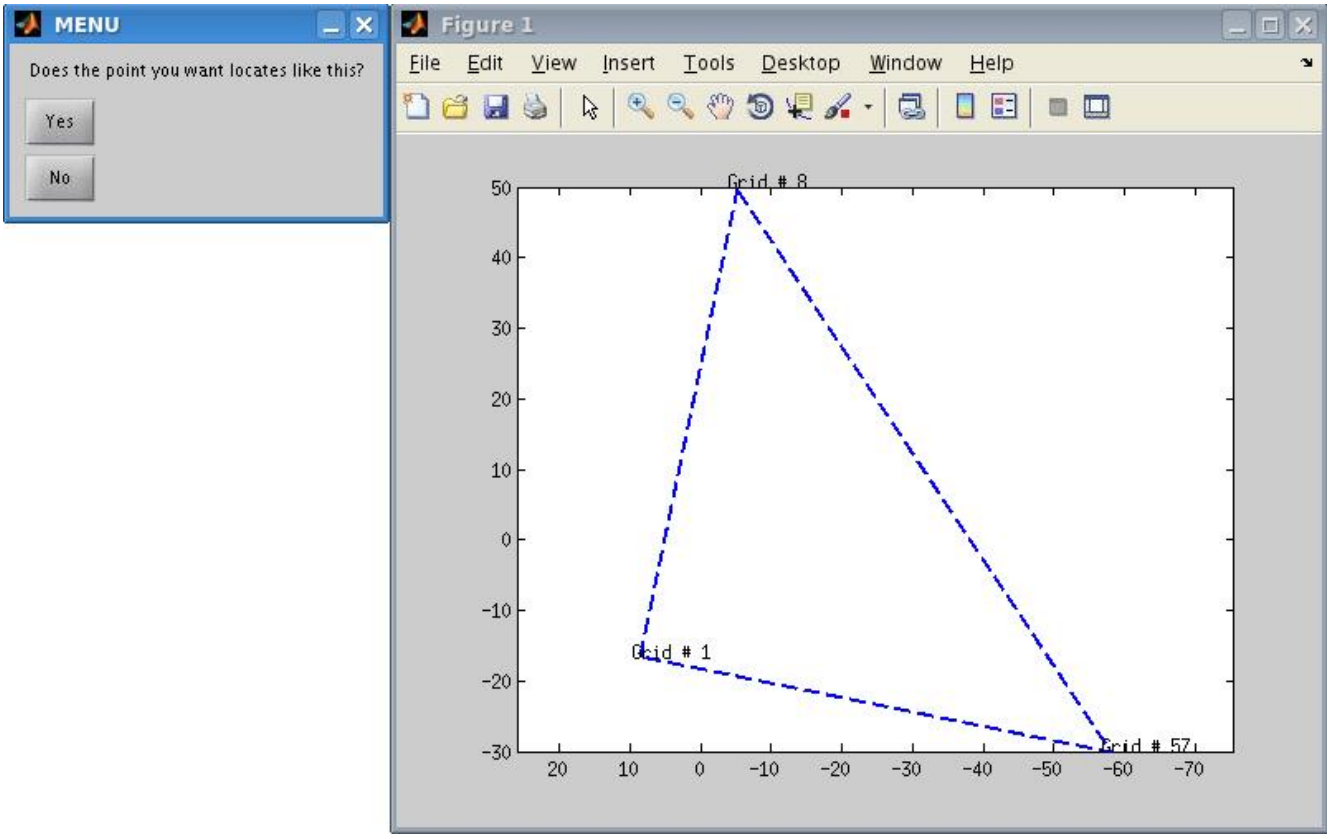
4. Select the hemisphere (lh, rh, or both)

5. Input the inter-electrode distance (mm) (Press Enter for default distance 10mm)

6. Select the size of the grid



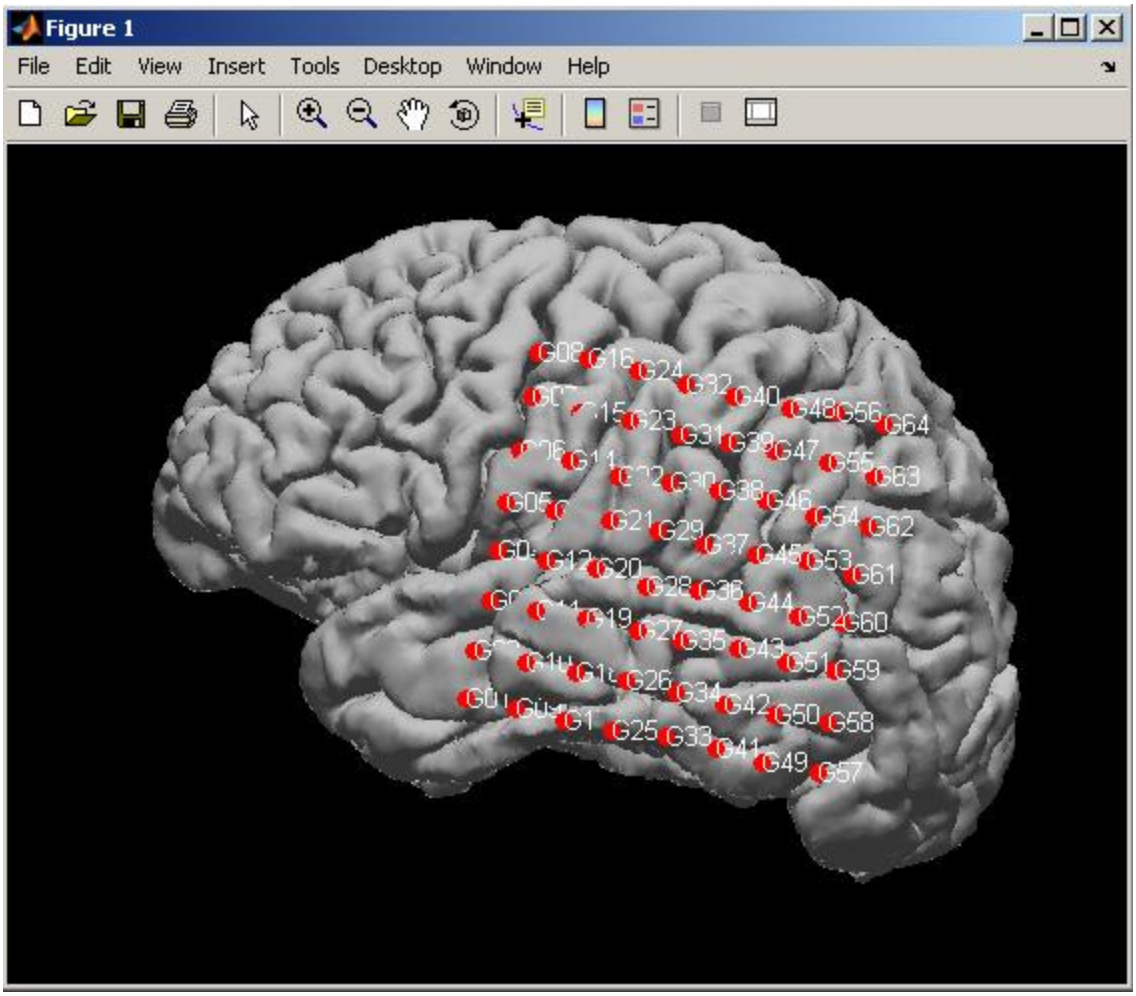
6.5.Verify the orientation of the initial grid points (If you pick up 3 or 4 initial points for the grid, then this window won't pop up)



7. calculating the mean and standard deviation of distance between nearest two electrodes. If no result satisfies with the std smaller than 1 and mean distance is 10+-1, manually input the NO. of result you think is good enough or type number '0' to exit and recheck the initial text file.

```
lh.pial-outer-smoothed file detected
rh.pial-outer-smoothed file detected
Calculating the grids.....fs_read_surf: reading triangle file...done (0.09 sec)
NO.     itr      distance mean(mm)     standard deviation(mm)     center location
-------------------------------------------------------------------------------------
1    -5.00             10.4987                0.5115             [ 274,-20,-9  ]
2    -4.70             10.5097                0.4913             [ 257,-20,-8  ]
3    -4.40             10.5246                0.4964             [ 240,-21,-7  ]
4    -4.10             10.5365                0.4845             [ 223,-21,-6  ]
5    -3.80             10.5498                0.4448             [ 206,-22,-5  ]
6    -3.50             10.5709                0.4518             [ 189,-23,-5  ]
7    -3.20             10.5926                0.4713             [ 172,-23,-4  ]
8    -2.90             10.6339                0.4712             [ 155,-24,-3  ]
9    -2.60             10.6474                0.5003             [ 138,-24,-2  ]
10    -2.30             10.6751                0.4931             [ 122,-25,-1  ]
11    -2.00             10.7024                0.4988             [ 105,-26,0  ]
12    -1.70             10.7538                0.5206             [ 88,-26,1  ]
13    -1.40             10.7905                0.5581             [ 71,-27,2  ]
14    -1.10             10.8960                0.5896             [ 54,-27,3  ]
Elapsed time is 143.533336 seconds.
Done
```

8. viewing the results on the brain surface



Misc Notes

Useful programs for MRI visualization

1. MRICRCO (PC, Linux & MAC) starts with 'mricro' in Unix terminal http://www.sph.sc.edu/comd/rorden/mricro.html
2. MRICRON (PC, Linux & MAC) http://www.sph.sc.edu/comd/rorden/mricron
3. FSLVIEW (Linux & MAC) starts with 'fslview' in Unix terminal http://www.fmrib.ox.ac.uk/fsl/fslview/index.html
4. 3DSlicer (PC, Linux, MAC) starts with 'slicer' in Unix terminal (http://www.slicer.org/)

Electrode Visualization

ntools_elec_plot

a stand-alone Matlab script for viewing the electrodes on brain surface. To do so:

1. In MATLAB: ntools_elec_plot
2. Select the subj_coor_*.txt file
3. Select the surface mat file
4. Select if (or not) to show the electrode labels and save into images
5. Choose to plot only the grid, strips, depth or both grid and stips.

ntools_elec_plotGroup

a stand-alone Matlab script for viewing certain electrodes on brain surface. It requires a different electrode coordinates text file: in the fifth column, instead of G/D/S, there are numbers e.g. 1~8, so you can choose to plot 2,4,5. Numbers can be any positive integers. Example text file shows below:

	A	B	C	D	E
1	G1	-40	50	1	9
2	G8	-42	-9	36	9
3	G64	-60	-42	-24	9
4	OF1	8	32	-36	2
5	OF2	-2	35	-35	2
6	OF3	-12	38	-33	2
7	OF4	-20	40	-28	3
8	AT1	-13	13	-41	3
9	AT2	-17	22	-48	3
10	AT3	-21	30	-52	4
11	AT4	-30	32	-48	4
12	MT1	-12	2	-41	4
13	MT2	-19	2	-47	4
14	MT3	-27	3	-54	4
15	MT4	-36	7	-57	5
16	PT1	-19	-65	-43	5
17	PT2	-27	-59	-41	5
18	PT3	-32	-50	-41	5
19	PT4	-40	-42	-44	6
20	PT5	-46	-35	-46	7
21	PT6	-52	-27	-45	7
22	DPMT1	-11	-5	-31	7
23	DPMT8	-42	6	-37	8
24	DAMT1	-17	-25	-24	8
25	DAMT8	-47	-7	-29	8