

BioEST™ ver. 1.5beta User Manual

Chang-Hwan Im (Ph.D.)

<http://www.bioest.com>

E-mail: ichism@elecmech.snu.ac.kr

imxxx010@umn.edu

1. What is BioEST™?

BioEST™ is a special edition of SNUEEG(<http://www.bioinverse.com>), which is a general purpose brain electrical source estimation software based upon cortically distributed source model [1-3]. In the title ‘BioEST’, EST represents ‘estimation’. The BioEST estimates brain electrical sources on a standard Talairach brain based on cortically distributed source model [4]. This software is very useful especially when there is no individual MRI T1 images or no head anatomical data. The main features of the BioEST are as follows:

- (1) Generalized source reconstruction software – easily applicable to any kinds of data with just slight modifications
- (2) Boundary element method (BEM) was used for forward calculation [5]. Fast matrix solver (LAPACK routine) was adopted.
- (3) Anatomical constraints are used. Linear (Wiener) inverse estimation is used for the reconstruction [6 – 8]. Cortical meshes are segmented and tessellated from MRI T1 images [9].
- (4) Accuracy of the software was verified extensively using several experimental data.
- (5) FOCUSS (Focal underdetermined system solution) algorithm can be used optionally [10].

Figure 1 shows the MRI T1 images of the Talairach brain and Figure 2 shows the tessellated brain cortical surface (interface between white and gray matter). Figure 3 shows the boundary element data sets used for the forward calculation.

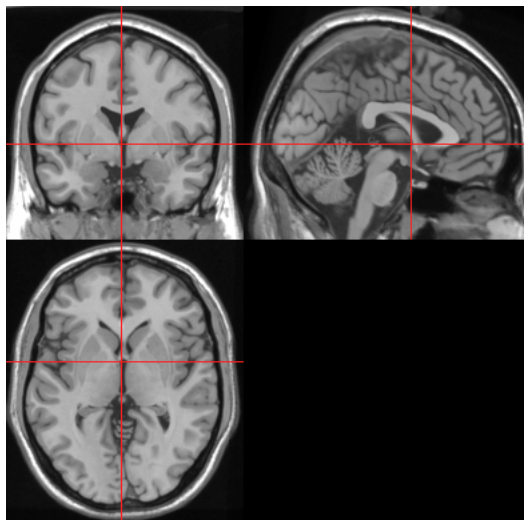


Figure 1. MRI T1 images of Talairach brain.

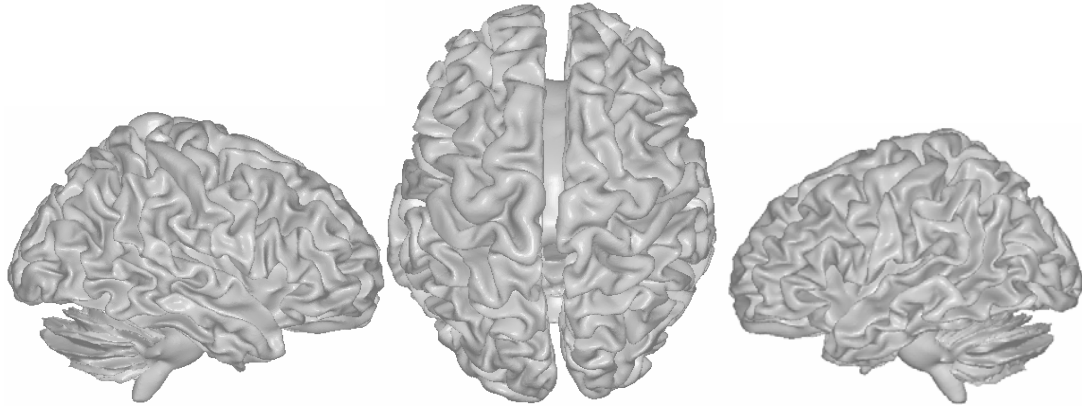


Figure 2. Tessellated cortical surface of Talairach brain.

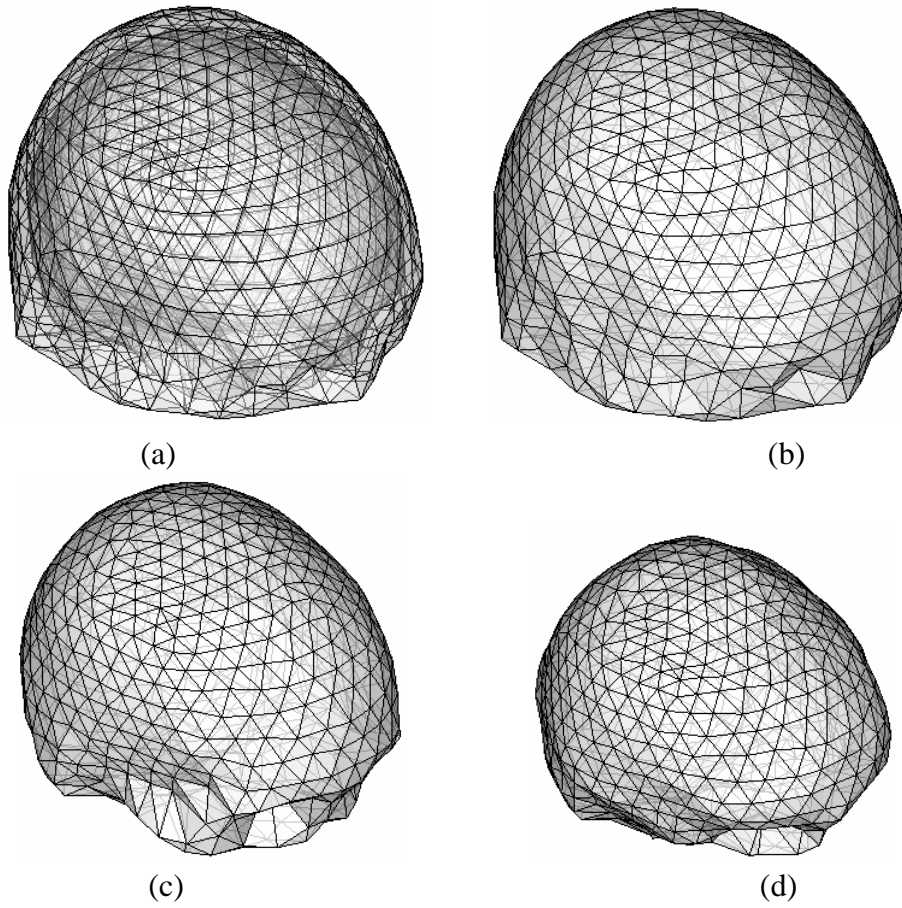


Figure 3. Boundary element models: (a) whole model; (b) scalp; (c) outer skull boundary; (d) inner skull boundary.

Conductivities of the forward model were assumed as typical values presented in Table 1 [11].

Table 1. Typical conductivity values for different regions.

Regions	Absolute Conductivity (S/m)	Relative Conductivity
Brain	0.22	1
CSF	1.79	8
Skull	0.014	1/16
Scalp	0.22	1

As for the electrode configurations, an extension of 10-10 system (10% system) was applied. The extended 10-10 electrode system is shown in Figure 4.

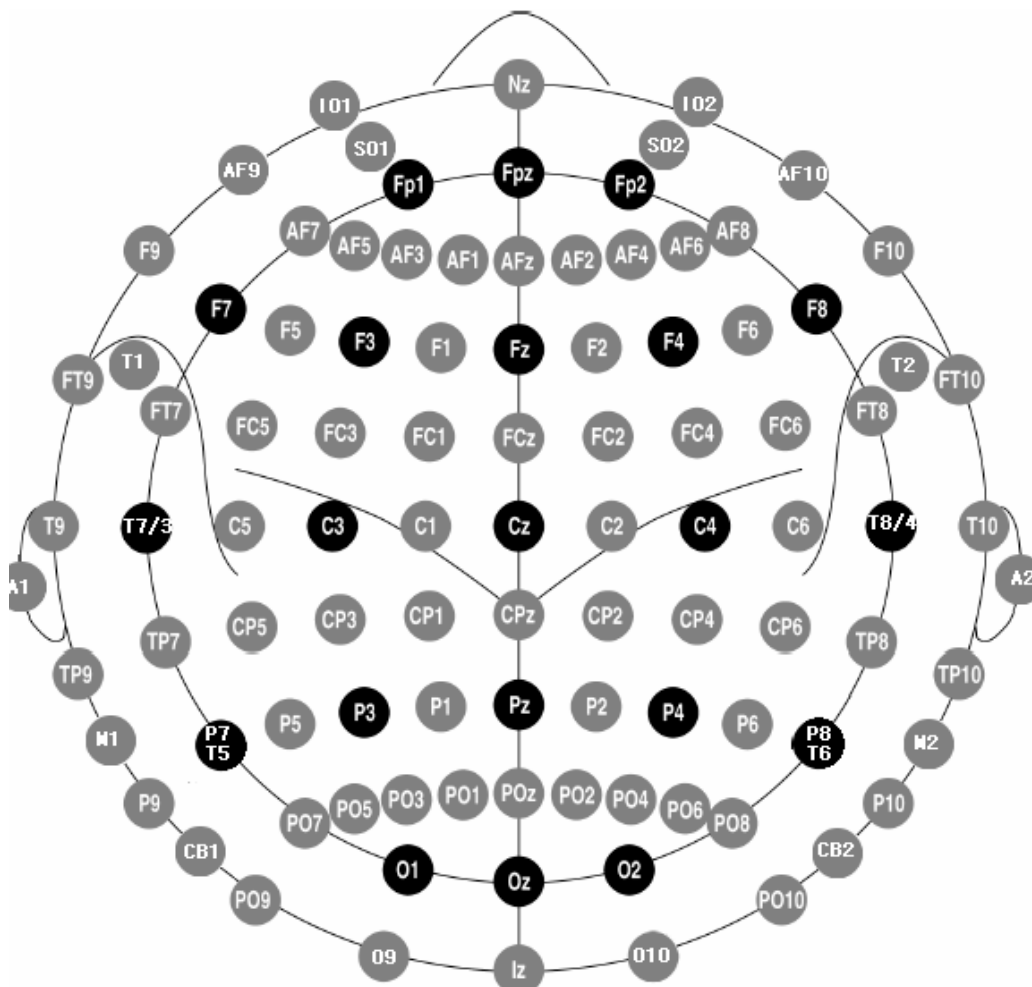


Figure 4. 10-10 electrode system used for BioEST™.

2. Installation of BioEST™

Required computer system

Microsoft Windows® 2000/XP
Pentium 4(2GHz) or compatible (recommended)
Memory 512Mbytes or higher (recommended)

Installation

Just execute < BioEST_setup.exe> and proceed according to the instructions.

(Very Important)

The software cannot detect blanks in folder or file names. E.g. you should not install the software in 'Program Files' folder, because there is a blank in the folder name. The default file path is "C:\BioEST\".

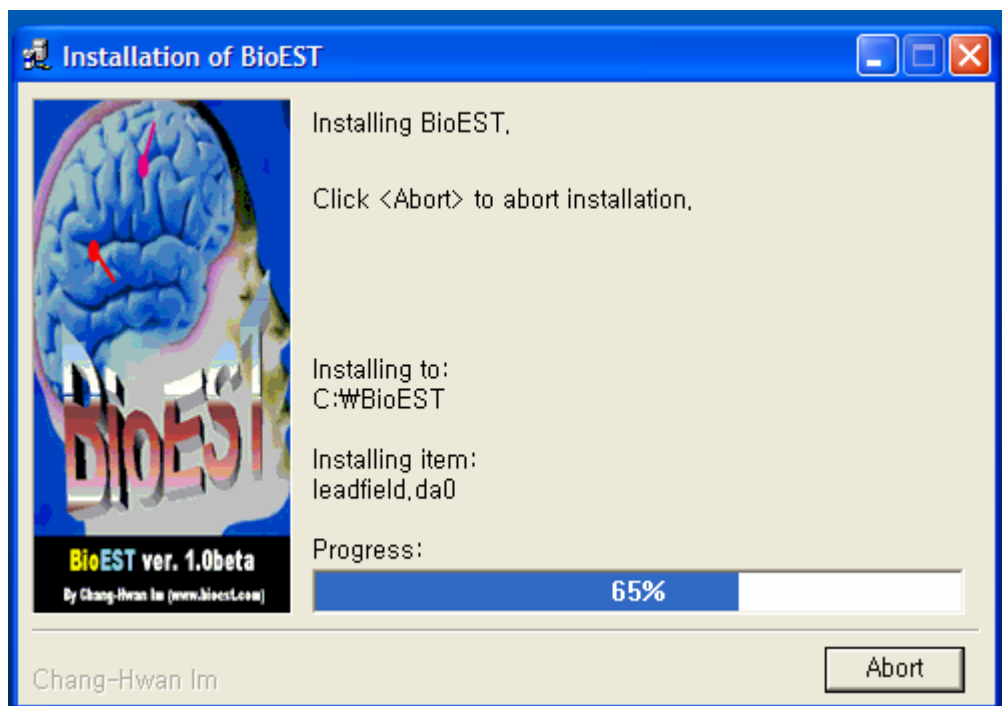


Figure 5. Installation of BioEST™

Start the Program

In the installed program folder, you can find the execution file named ‘BioEST.exe’. You can start BioEST™ just by clicking it.

Uninstall the Program

After the installation, you may find a new folder named ‘BioEST’ at ‘start menu → programs’. There would be an icon named “Remove BioEST”.

3. Example of an Execution

At the first stage, you will encounter a blank window as shown in Figure 6. There are five main menus – *File*, *Electrode*, *Analysis*, *About* and *Quit_BioEST*. In this manual, *About* and *Quit_BioEST* will not be explained.

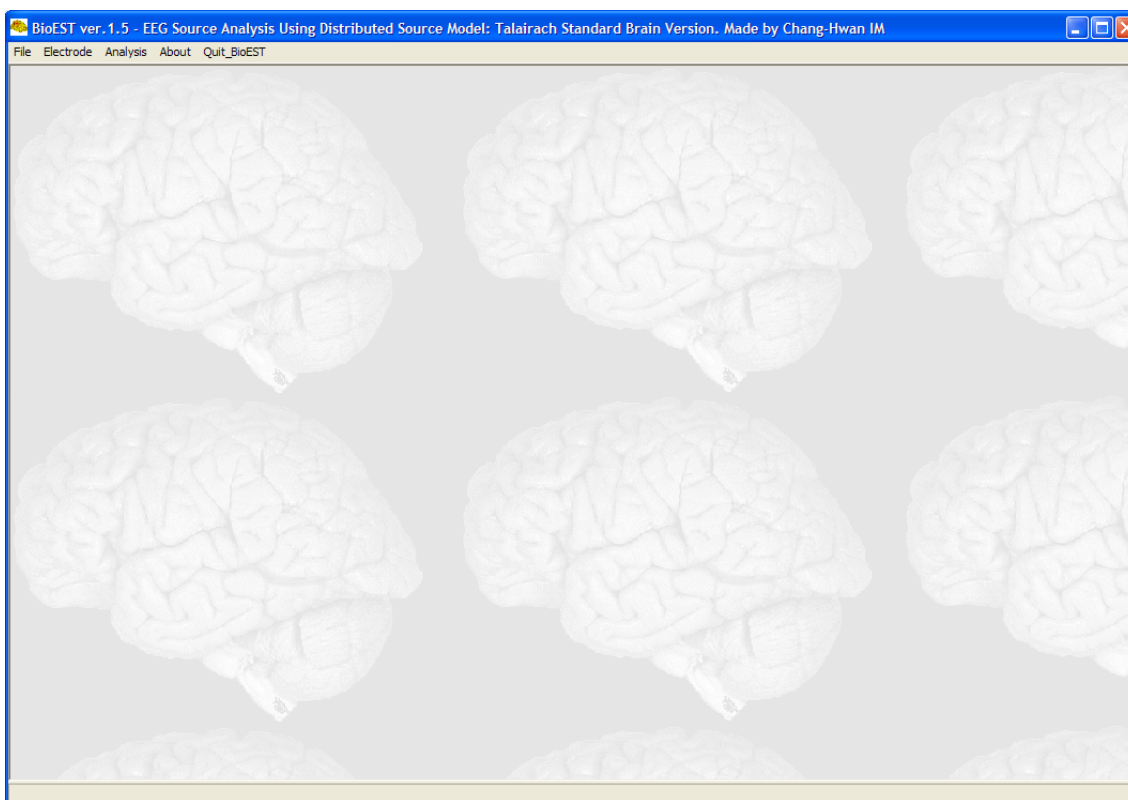


Figure 6. Initial window of the BioEST.

3.1. File Menu

- (1) **New:** Closing all windows and resetting all materials except current working directory
- (2) **Working Directory:** Setting working directory (folder). All output files will be generated in the directory. **If one doesn't set this, the program folder will be used as the working directory.**
- (3) **Preference:** Setting preference. Default preference is shown in Figure 7. If one changes the values and clicks 'confirm' button, the settings will be saved and used again for next executions.
 - **Number of FOCUSS Iterations (Integer, should be larger than 1)** sets the number of iterations in FOCUSS algorithm. If the value is set as 1, no FOCUSS iteration will be executed.
 - The BioEST supports two **Post-Types**: Intensity and Power of the source. Power is recommended for more focalized images.
 - **Threshold for Cutting Small Intensities (0-1):** If the value is set 0, intensity or power at all source positions will be presented. If the value is set 0.2, sources which have source values less than 20% of maximum value will be eliminated in the post-processing. Figure 8 shows the examples of source distribution with respect to different threshold values.
 - **Plot Color:** Current version of BioEST support only three types of color maps: Yellow(low)-Red(high), Red(low)-Yellow(high). Green-Yellow-Red. More contour colors will be supported in the upcoming version.

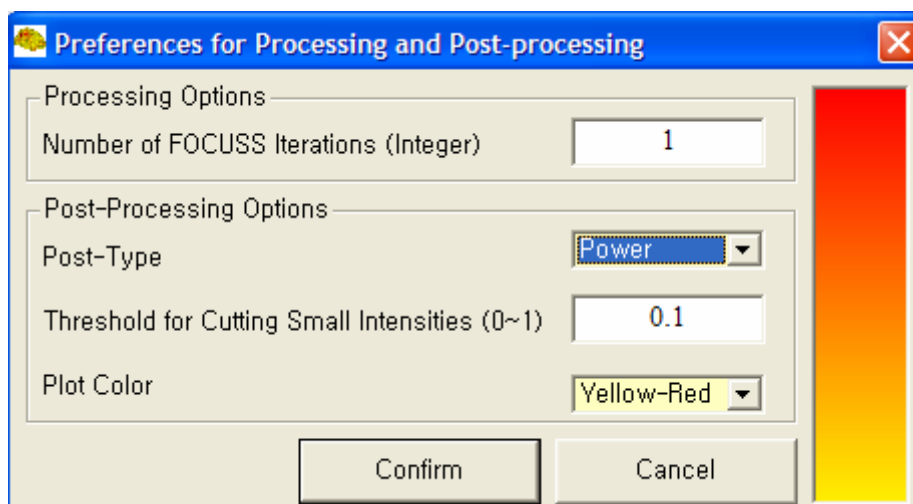


Figure 7. Setting preferences.

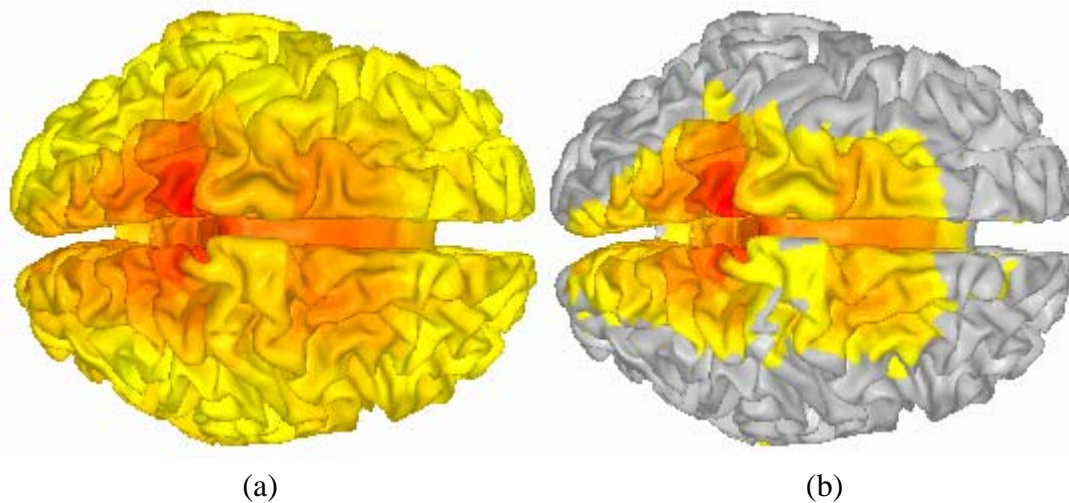


Figure 8. Effect of threshold values on the post processing: (a) threshold = 0; (b) threshold = 0.2.

3.2. Electrode Menu

The *Electrode* menu sets electrode data file. If you already have a formal electrode file, you have no need to execute this menu. The form of the electrode data file is

(number of electrodes)

(list of electrode names – standard names of 10-10 system; one can find the name in the left side figure of the window)

For example,

3

FPz

O1

A2

(Note – FPZ, Fpz, FPz, fpz, etc. are regarded as a same electrode name.)

You can make the file manually, but it seems much easier to use the *Electrode* menu in BioEST™. Figure 9 shows the initial window of the electrode data editor. Current version supports only standard 10-10 system, but more electrode systems and user-defined systems will be merged to the next versions.

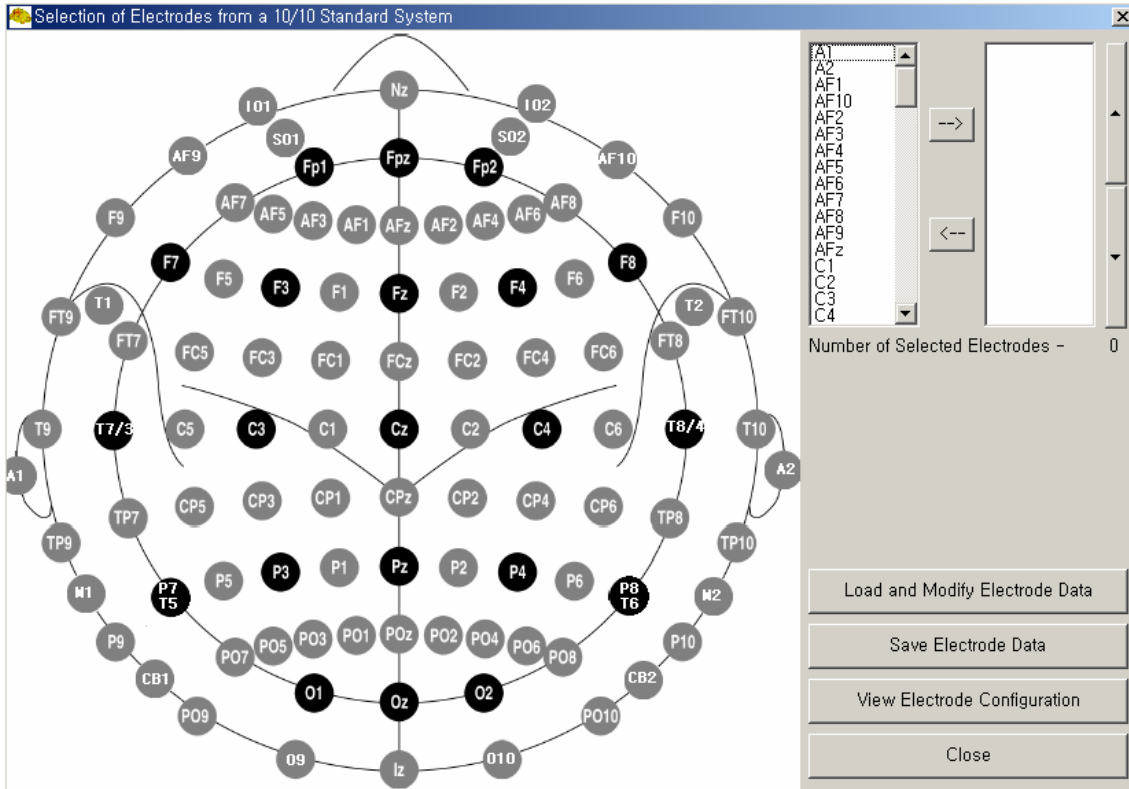


Figure 9. Electrode Editor

Left large figure show the configuration of the extended 10-10 system. You can select an electrode by choosing an electrode name in the left listbox and clicking right arrow button. In the same way, you can remove the selected electrode using left arrow button. The up/down keys are used to adjust orders of the electrodes selected (Just try it!). You can load or save electrode files using the command buttons listed below the listbox. If you click the 'View Electrode Configuration' button, you can check the electrode configuration as shown in Figure 10. The viewer is the same program as the post-processor. It is recommended for you to select 'perspective' view instead of 'orthographic' view. If you select 'Cull Face' in the 'View Option', the hidden electrodes will not be shown. Mouse movement with left button click changes view angles and movement with right button click enables zooming-in and zooming-out. Please refer the detailed description in the post-processor section.

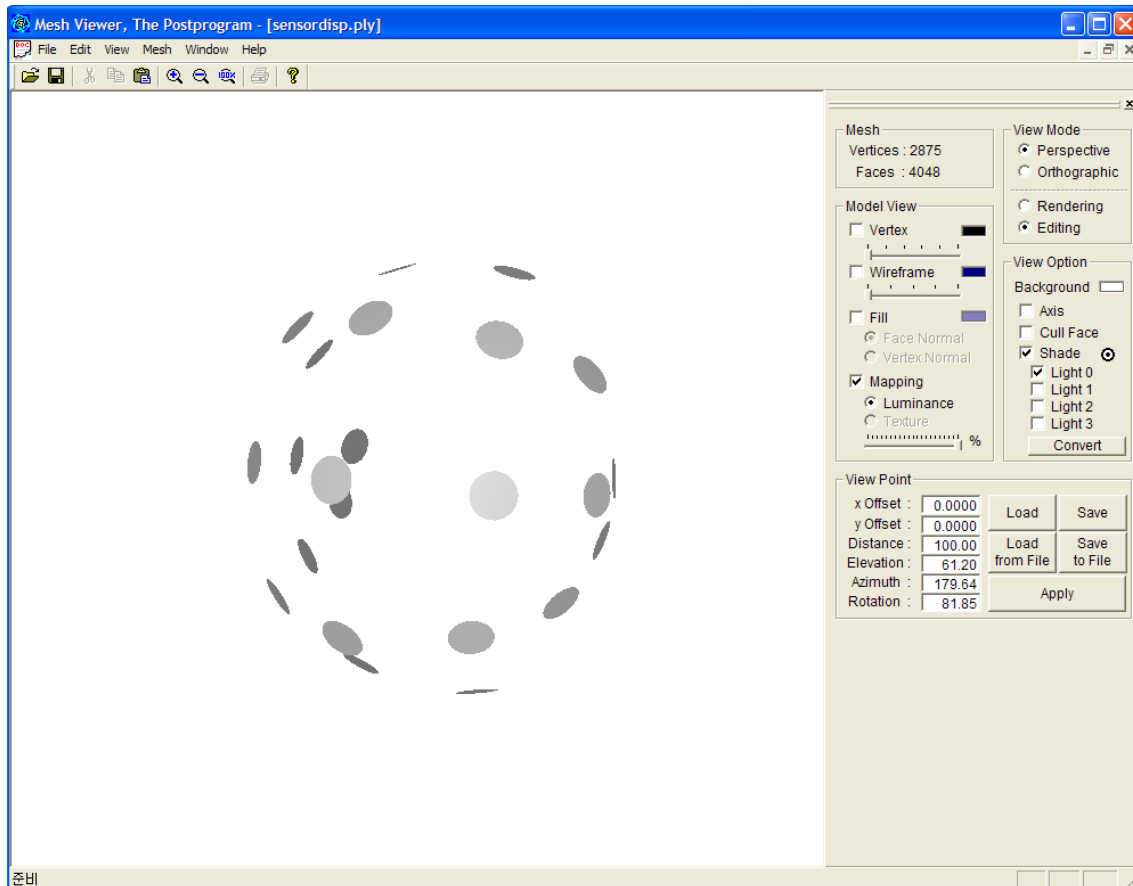


Figure 10. Electrode configuration viewer.

3.3. Analysis Menu

The *Analysis* menu is the main part of this software. The menu consists of two parts. One is ‘Run Analyzer’; the other is ‘View BEM Geometry’. ‘View BEM Geometry’ is just a simple visualization module which shows the standard BEM geometry used in this software (This is simple enough to be skipped.).

To execute the Analyzer, click the ‘Run Analyzer’ menu.

Before the analysis, you should read an EEG measurement data file (see Figure 11).

The data file should have the following form:

(Potentials for Sensor 1) (Potentials for Sensor 2) ... (Potentials for Sensor N)

The columns represent sensors, the orders of which should coincide with the electrode data edited in *Electrode* menu. The rows represent sampled times. The following example shows EEG measurement data for 4 sensors and 6 time samples.

-0.7517 -1.1581 -0.5287 -1.0366
-0.929 -1.3317 -0.6726 -1.0155
-1.0754 -1.4867 -0.8416 -1.0123
-1.1861 -1.6143 -1.0231 -1.0356
-1.2602 -1.7083 -1.206 -1.0875
-1.3023 -1.767 -1.3792 -1.1623

One can view the ASCII data file simply by clicking **View File in NotePad** button.

If there are some comments in your data file, you can skip the useless lines using **Skip First** **Rows**. Sometimes, there are some additional columns for data index or time index. You can skip those columns using **Skip First** **Columns**.

Then, one should fill out 'the number of data (time) samples and electrodes'. One should also fill out starting and ending times and click OK button.

If all the data are read properly, you will encounter another file-menu to choose electrode data file. Please choose the electrode files that you made previously.

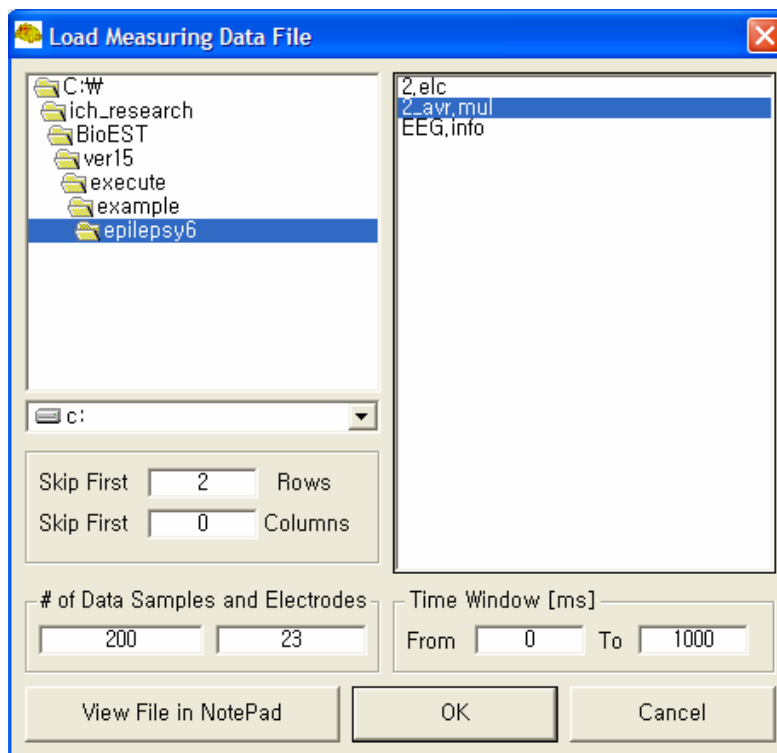


Figure 11. Load measuring data file

Then, you will see the main analysis window as shown in Figure 12. At the left part of the window, you can observe the measured signal patterns of all sensors. You can scroll the graph using the scroll bar located below the picture. If you move your mouse on the picture, some numbers will be presented around the mouse pointer. The number represents a time slice where you are indicating with your mouse pointer.

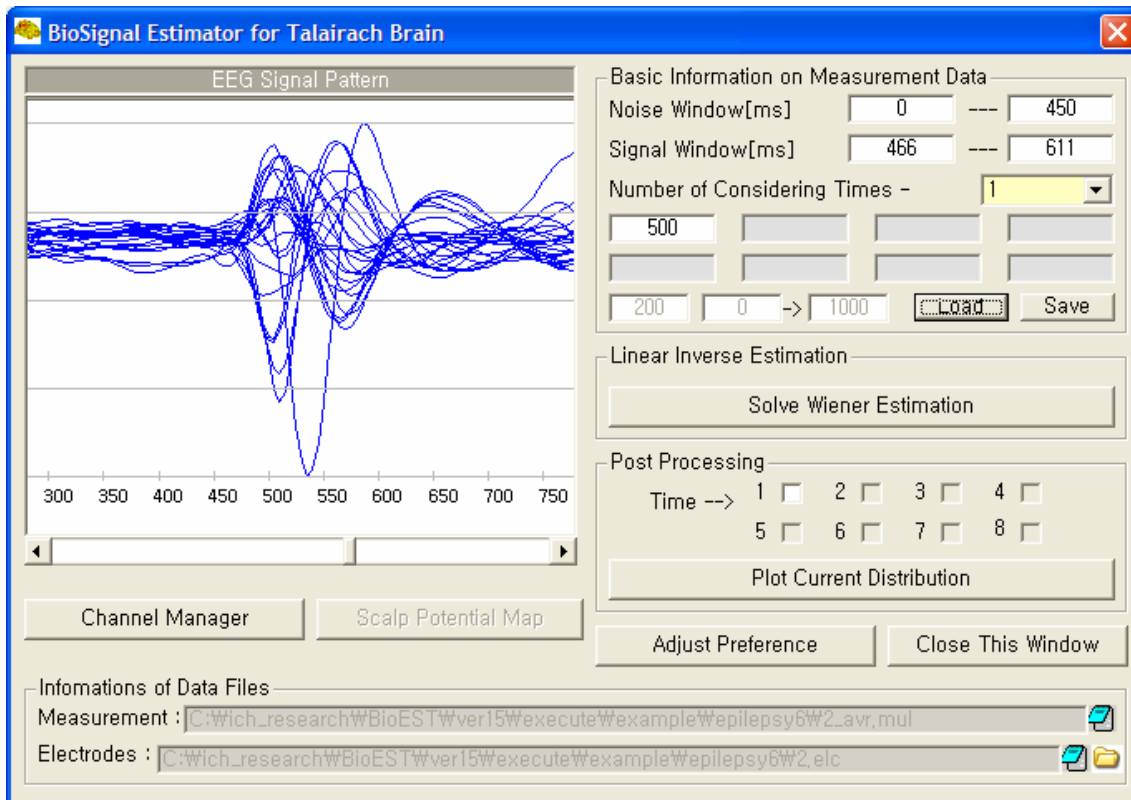


Figure 12. Main analysis menu

If you click the **Channel Manager**, then a new window will appear as shown in Figure 13. In this window, you can select specific channels and show the waveforms. You can move some channels using left and right arrow buttons or 'Move All Original to Selected' / 'Move All Selected to Original' buttons. Or, you move some channels to 'Bad' channel list using the other left and right arrow buttons. You can visualize selected channels and bad channels using **Draw Waveform of Selected Channels** and **Draw Waveform of Bad Channels**, respectively. After selecting the bad channels, you can reject those channels by clicking **Reject Selected Bad Channels** button. After the bad channel rejection process, close the window and go back to the main analyzer window.

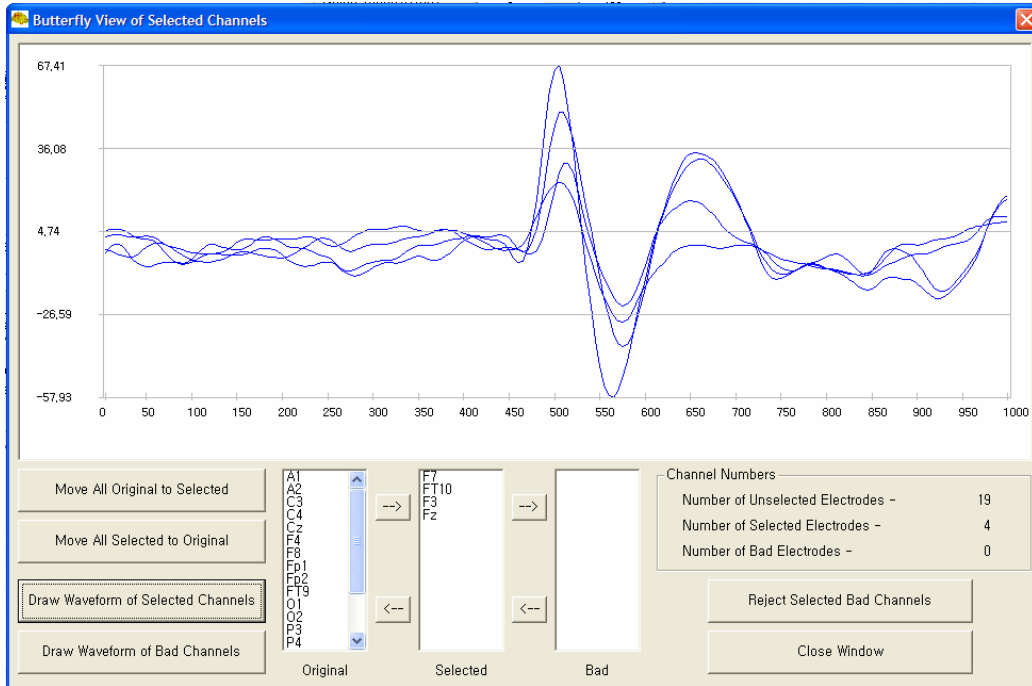


Figure 13. Channel Manager

Then, you should fill out all the blanks for noise window, signal window, and reconstructing times. **Do not forget to Save the file!!!** The data will be saved in 'EEG.info' in the working directory. If this is not your first time to analyze the data, you can **Load** the data from 'EEG.info'.

Now, all the pre-processing processes are finished. Click 'Solve Wiener Estimation' button, and wait for a moment. After the execution of DOS-based program shown in Fig. 14, you can see the reconstructed current distribution.

```

C:\BioEST\WienerSOL.exe
--- Analysis of EEG Measurement Data ---
--- Ver. 4.5 ---
--- Programmed by ICH, Dec. 18, 2004. ---
--- Wiener Estimation, Realistic Brain ---

Now Reading Data Files...
Reading Information File - IEEG.info1
[cortex.dat] - cortical mesh data for post-processing
[deci_mesh.dat] - decimated cortical surface mesh data
Now Reading Liield Field Matrix of Talairach Atlas
Reading Sensor Data File
Reading Measured Electric Potential File

Now Calculating Noise and Signal Covariance Matrix...
Considering Average Reference in Lead Field Calculation
Lead Field Normalization

Now Solving Minimum Norm Estimation...

Reconstructing Time(ms) is -- 500.0000

FOCUSS iteration - 1
Now Multiplying Matrix...

Write Data to ... wiener1.ply

```

Figure 14. Execution of Main Solver

Then, select a time (times) and click **Plot Current Distribution**, and you can see the post-processor as shown in Figure 15.

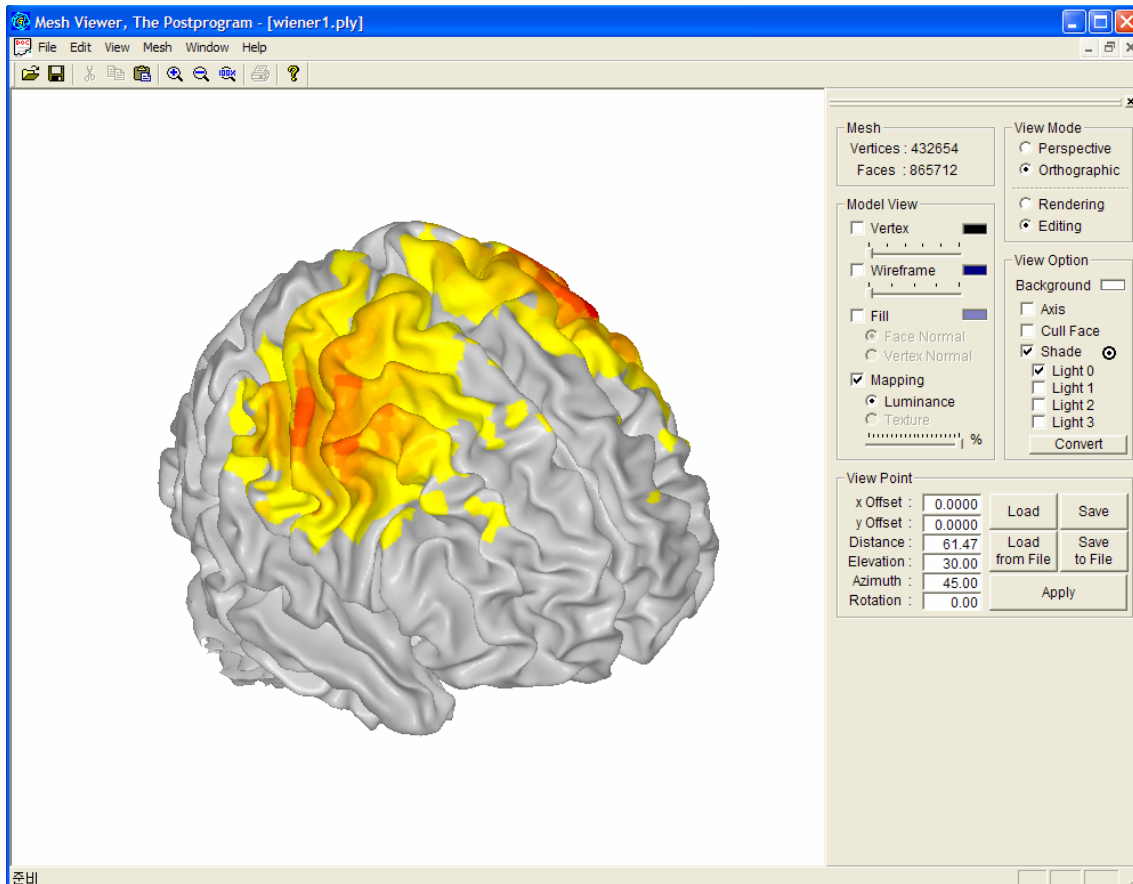



Figure. 15. Post-processor.

3.4. Post-Processor

This section describes how to use the post-processor. Figure 15 shows an example of the execution of the post-processor. There are many functions implemented in this software.

- Basic Function 1 – View Points and zooming in/out : You can use mouse to change view points and size of the results. If you move your mouse with left-button click, you can rotate the figure. If you move your mouse with right-button click, you can zoom in/out the figure. You can manually input the parameters using the menu shown in Figure 16. You can also load and save the view point information. You can adjust the speed of rotation and zooming using  %, which is just below the Mapping menu.

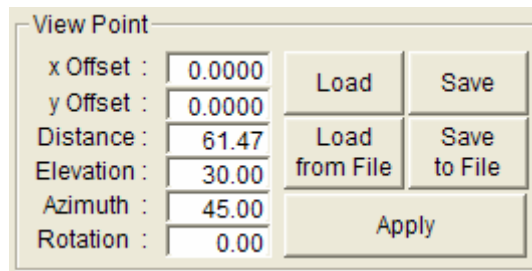



Figure 16. Menu for adjusting view points and size of the figure

- Basic Function 2 – Change Lights : If you click  mark with your mouse, then a new window shown in Figure 17 will show up. You can change directions and intensities of lights and add more lights. You can also save and load your own information. If you click ‘Apply’ you can see the results immediately.

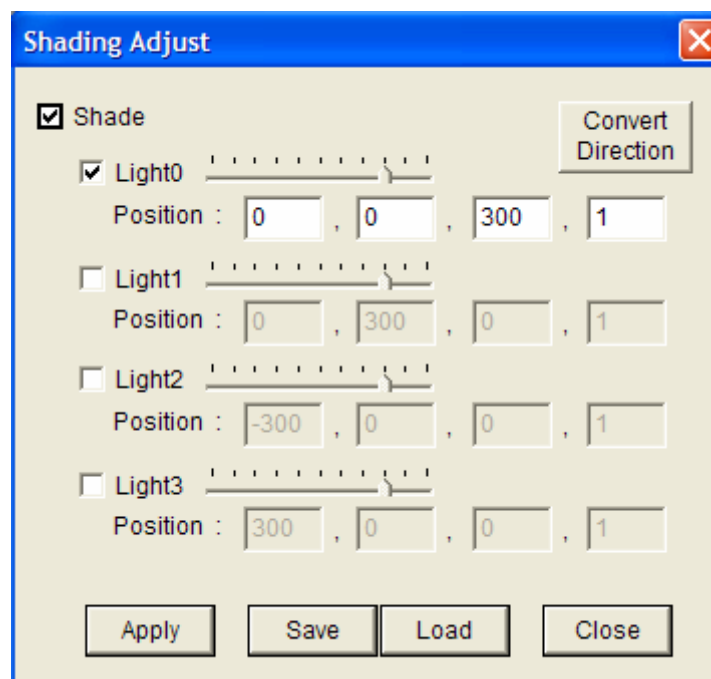



Figure 17. Shading Adjust

- Optional Functionalities : You can see the cortical surface meshes and vertices by selecting **Wireframe** and **Vertex**, respectively. You can see the geometry of the cortical surface used in this software by clicking **Fill** menu. You can change the colors by clicking color buttons like . You can also change the view mode from orthographic (default) to perspective. In view option, you can also visualize the axis with three different colors.

- Editing : This option is sometimes very useful to see deep brain activations. You can edit the figure only when 'Editing' is selected instead of 'Rendering'. Figure 18 shows an example. You can select a region which will be removed or added using 'Shift + left mouse button click'. Pressing 'r' in keyboard will lead to remove the selected region, as shown in Figure 19. **It is recommended to select 'Cull Face' in 'View Option'.**

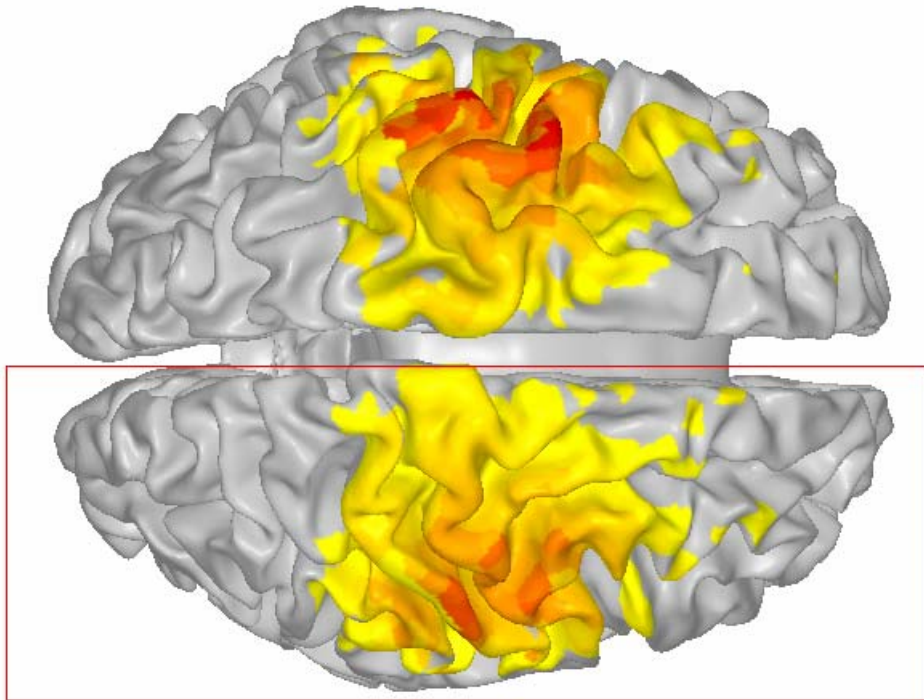


Figure 18. An example for editing option

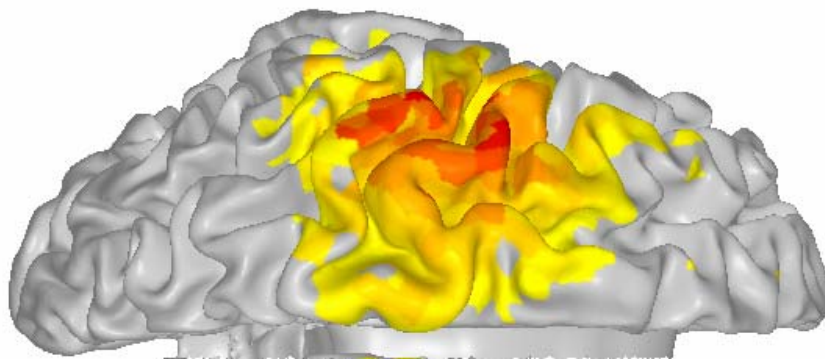


Figure 19. Cortical surface after removing a selected region.

If you rotate the figure, you can see the ‘inside of the brain’ as shown in Figure 20.

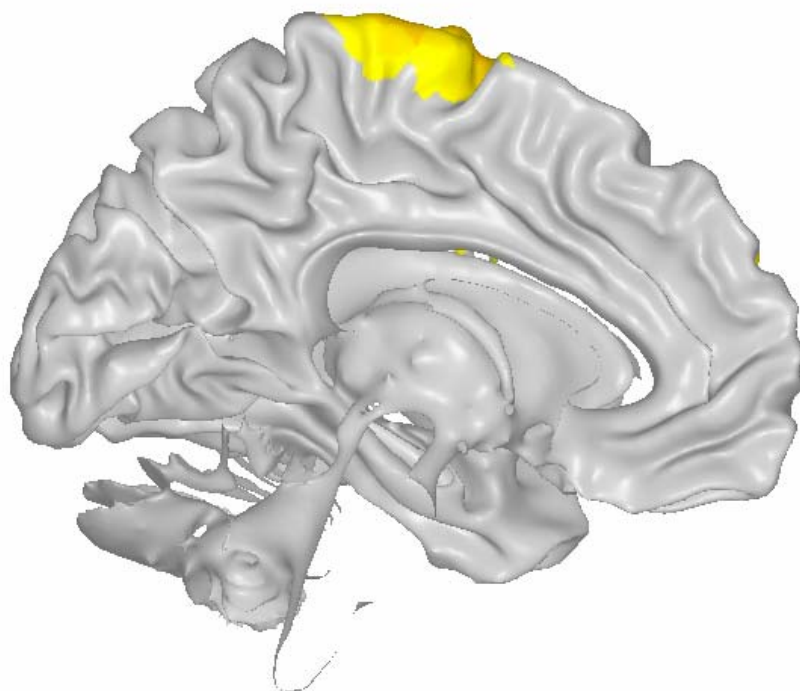


Figure 20. Remaining regions after rotating the figure.

You can return to the original figure by pressing ‘c’ in the keyboard. If you want to add some regions, select the region and press ‘a’ button. Figure 21 shows an example of the ‘editing’ function applied to ‘View BEM Geometry’ menu (Cull Face option was not selected).

References

- [1] A.M. Dale and M.I. Sereno, “Improved localization of cortical activity by combining EEG and MEG with MRI surface reconstruction: a linear approach,” *J. Cognit. Neurosci.*, vol. 5, pp.162-176, 1993.
- [2] C.-H. Im, K.-O. An, H.-K. Jung, H. Kwon, Y.-H. Lee, “Assessment criteria for MEG/EEG cortical patch tests,” *Phys. Med. Biol.*, vol. 48, pp.2561-2573, 2003.
- [3] S. Baillet, J.J. Riera, G. Marin, J.F. Mangin, J. Aubert, and L. Garnero, “Evaluation of inverse methods and head models for EEG source localization using a human skull phantom,” *Phys. Med. Biol.*, vol. 46, pp.77-96, 2001.
- [4] J. Talairach, and P. Tournoux, *Co-planar stereotactic atals of the human brain*, 2nd ed., Stuttgart: Thieme, 1988.

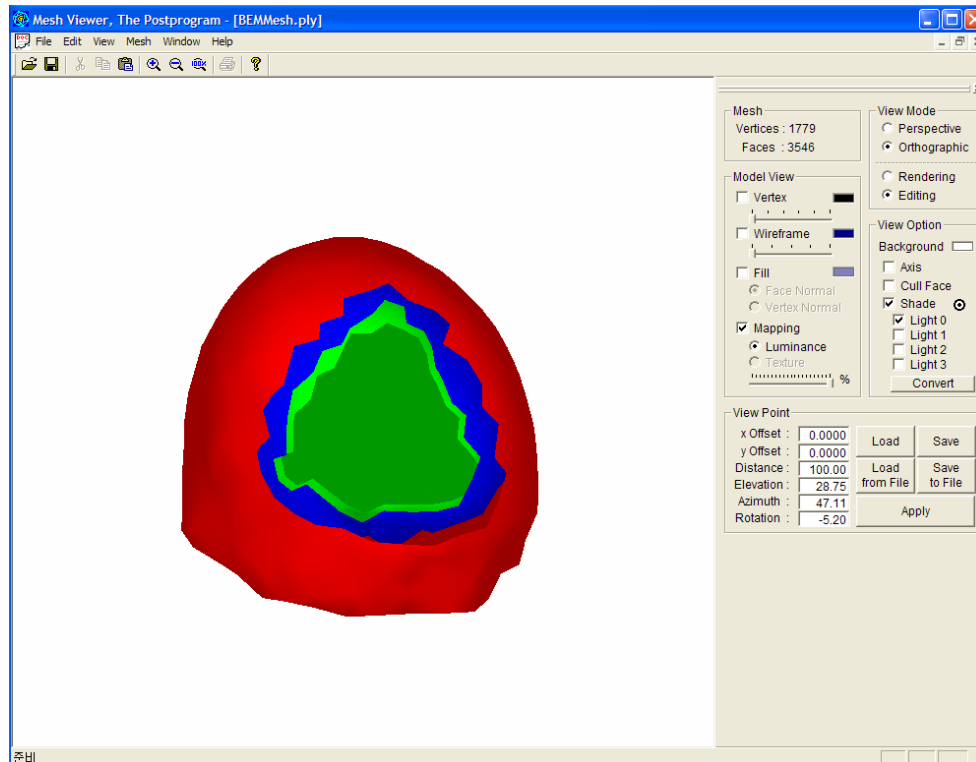


Figure 21. Example of 'Edit' function.

- [5] J.C. Mosher, R.M. Leahy, and P.S. Lewis, "EEG and MEG: forward solutions for inverse methods," *IEEE Trans. Biomed. Eng.*, vol. 46, pp.245-259, 1999.
- [6] K. Sekihara and B. Scholz, "Generalized Wiener estimation of three-dimensional current distribution form biomagnetic measurements," *IEEE Trans. Biomed. Eng.*, vol. 43, pp.281-291, 1996.
- [7] A. van Oosterom, "The use of the spatial covariance in computing pericardial potentials," *IEEE Trans. Biomed. Eng.*, vol. 46, pp.778-787, 1999.
- [8] A.K. Liu, A.M. Dale, and J.W. Belliveau, "Monte Carlo simulation studies of EEG and MEG localization accuracy," *Hum. Brain Mapp.*, vol. 16, pp.47-62, 2002.
- [9] A.M. Dale, B. Fischl, and M.I. Sereno, "Cortical Surface-Based Analysis I. Segmentation and Surface Reconstruction," *Neuroimage*, vol. 9, pp.179-194, 1999.
- [10] I.F. Gorodnitsky, J.S. George, and B.D. Rao, "Neuromagnetic imaging with FOCUSS: a recursive weighted minimum norm algorithm," *Electroencephalogr. Clin. Neurophysiol.*, vol. 95, pp.231-251, 1995.

- [11] J. Haueisen, C. Ramon, M. Eiselt, H. Brauer, and H. Nowak, "Influence of tissue resistivities on neuromagnetic fields and electric potentials studied with a finite element model of the head," *IEEE Trans. Biomed. Eng.*, vol. 44, no. 8, pp.727-735, 1997.