

This is an instruction on how to use NFRI functions.

Last updated on 11/14/2009

Please unzip the zip file, "nfri\_functions.zip", and save the unzipped folder "nfri\_functions" to any directory. AVOID USING DIRECTORY NAME with MULTI-BYTE CHARACTERS in the path to the folder so that Matlab can well find the appropriate folder.

You need Matlab to run the tools. Version 7.1 or later would work fine. Run Matlab, and go to the *nfri\_functions* directory or set a path to the directory. Then, you are ready for enjoying the tools.

### **Individual spatial analysis with "nfri\_mni\_estimation"**

This function probabilistically registers individual subject's NIRS probe positions obtained in a real-world coordinates to the MNI space. Instead of using subject's own MRI dataset, which is not obtained in a typical NIRS measurement, the function pick up brains in the reference database, and "probabilistically" registers the subject's NIRS probe onto the MNI-152 compatible canonical brain that is optimized for NIRS analysis. For each NIRS probe position, a set of MNI coordinates (x, y, z) with an error estimate (standard deviation) will be calculated.

Usually, real-world coordinates for NIRS probe positions are measured using a magnetic 3D digitizer available from Polhimus. For a Fastrack model, a special GUI is available (scheduled to be released by the end of June, 2009). For a Isotrack and Patriot working with Hitachi optical topography instruments, a special data converter working with ".pos" files is available (see special instructions below). How about users working with other models? Don't worry, our function works pretty well as long as the data are properly formatted.

#### Working with pos file

A tool termed *pos2csv* convert *pos* file into *origin* and *others* files necessary for the probabilistic registration. Here is how to use it.

1. Ask a medical representative of Hitachi Medical Corporation to locate where pos files are stored. Get them anyhow.

2. On the Matlab command window, type “pos2csv”.
3. Select the pos file from the selector. For example, open “s01.pos” stored in “nfri\_functions/sample/pos”.
4. A pair of origin and others files are generated. For example, “s01\_origin.csv” and “s01\_others.csv” will be generated.
5. Data are ready for *nfri\_mni\_estimation*.

#### Data preparation

Before preparing data for NIRS positions, you have got to master how to measure them using a 3D magnetic digitizer. The art of proper measurement requires some technical tips with a dozen of minor details, so I will devote sometime later to describe it. For the time being, do your best to get real world coordinates for reference points and NIRS probe positions.

The function requires at least four of the following reference positions:

Iz, Nz, AL, AR, Fp1, Fp2, Fz, F3, F4, F7, F8, Cz, C3, C4, T3, T4, Pz, P3, P4, T5, T6, O1, and O2.

AL and AR stand for left and right preauricular points, respectively. Other nomenclature is according to 10-20 system

Preferably, the reference positions should be spatially separated with a good balance. For example, combination of Iz, Nz, AL, AR and Cz is great. If you measure the frontal lobe, Nz, AL, AR, Fz and Cz might be good. In a nut shell, select several points that are easy to measure (more than 4). The reference points will be updated in future releases.

The real world coordinates for the reference positions should be stored in a csv file called an origin file as attached as in a demonstration (stored in /nfri\_functions/sample). For example, in the file named “nfri\_mni\_estimation\_origin.csv”, the first column indicates the name of the reference positions. The word “HS” stands for “head surface”. The second, third and fourth columns indicates x, y, and z coordinates. Please insert 3D coordinates for the reference positions of your preference and leave the others blank. The function reads only the indicated reference positions.

The real world coordinates for the NIRS probe positions should be stored in a

csv file called an *other* file as attached as in a demonstration (stored in /nfri\_functions/sample). For example, in the file named “nfri\_mni\_estimation\_others.csv”, the first column indicates the name of the NIRS probe positions. Any name (but not multi-byte characters) is all right, so please insert any name of your preference. The second, third and fourth columns indicate x, y, and z coordinates. Please insert 3D coordinates for the NIRS probe positions of your preference. As long as a row contains name, x, y, and z values, the function can process the data anyhow. So, if you would like to estimate channel locations, you only have to pick up an optode pair and calculate the coordinates for the midpoint, and use them as real-world coordinates for the channel (an instant calculator will be available soon).

How to use the function

Type “nfri\_mni\_estimation” in the command window of MATLAB.

1. A GUI will guide you to open an “origin” file.
2. Another GUI will guide you to open an “others” file.
3. Another GUI will ask you to choose the reference positions of your preference. Pick up at least four positions, and click “OK”.
4. Wait for some dozen seconds, and you will get an Excel file starting with today’s date on the directory “/nfri\_functions/sample”, storing some parameters of importance for further analysis.
5. Please refer to our paper (Singh AK et al. Neuroimage, 2005) for details. Briefly, *WSHatC* (WS standing for within subject) are MNI coordinates for probe positions in the cortical surface appearing in the order indicated in the selected *others* file. *WSHatH* are the estimated probe positions in the head surface. *WS SDC* indicates standard deviations for the estimation on the cortical surface. The first to third columns represent SDs along x, y, and z axes, while the third column indicates composite SD. *WS SDH* indicates standard deviations for the estimation on the head surface.
6. In the figure entitled “Estimation result”, red dots are the real-world reference points transferred to the MNI space. Blue dots are the reference positions in the MNI space (only mean values are shown). So, if the red and blue points are located close, you can guess transformation has been successful.

7. Brown dots indicate distribution of head surface registration among reference brains, whose mean is indicated in pink. This is projected back onto the hypothetical head surface (green), and projected on the cortical surface indicated in white.

8. In the figure entitled "Estimation result (mean points and each SD) X/X", white circle regions indicates the probabilistic boundary of estimation defined by standard deviation. The data numbers are indicated as appearing in the *others* file.

\*The function is a bit heavy. If it stops running for unknown reason, first close Matlab and run it again.

With respect to the single subject's analysis, that's it. For group analysis, repeat the above procedure for the number of subjects (sorry, we have not updated a batch file), and go ahead for the following group procedure.

#### References

For use of this function, please cite the following reference.

If you were to choose one, please cite Singh AK et al.

Spatial registration of multichannel multi-subject fNIRS data to MNI space without MRI.

Singh AK, Okamoto M, Dan H, Jurcak V, Dan I.

Neuroimage. 2005; 27(4):842-51.

PMID: 15979346

If you are generous enough, please add the two more.

Automated cortical projection of head-surface locations for transcranial functional brain mapping.

Okamoto M, Dan I.

Neuroimage. 2005;26(1):18-28.

PMID: 15862201

Three-dimensional probabilistic anatomical cranio-cerebral correlation via the international 10-20 system oriented for transcranial functional brain mapping.

Okamoto M, Dan H, Sakamoto K, Takeo K, Shimizu K, Kohno S, Oda I, Isobe S, Suzuki T, Kohyama K, Dan I.

Neuroimage. 2004;21(1):99-111.

PMID: 14741647

Thanks in advance for your citation!.

### **Group spatial analysis with “MultiSubject4\_0”**

This tool sums up the results of individual analyses to yield group analysis data. This is just a beta version, so stored in an independent directory. But it works fine. Here is the actual procedure.

1. Prepare an empty folder.
2. Save all the output excel files that were generated by “nfri\_mni\_estimation” in the folder.
3. From the Matlab command window, go to *MultiSubject4\_0* directory, and type “ReadingM”.
4. In the window appearing, select the folder created in the step 2 (for demonstration go and select “/ nfri\_functions/MultiSubject4\_0/DATA/SampleDataN5”).
5. Wait until the process is done.
6. You will get an Excel file starting with today’s date on the directory in which you are working (in this example, “/ nfri\_functions/MultiSubject4\_0/DATA/SampleDataN5”). This stores some parameters of importance for further analysis.
7. Please refer to our paper (Singh AK et al. Neuroimage, 2005) for details. Briefly, *HATC* stores mean cortical surface MNI coordinate values across the subjects. *SDtC* contains a single column, representing composite standard deviation of the mean cortical surface MNI coordinate values across the subjects.
8. If you repeat the same procedure, please remove the previous result file from the directory or delete it. Otherwise, previous data will be included in your current data processing.

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## **Anatomical labeling with**

**“nfri\_anatomlabel\_final”**

This function reads a list of MNI coordinate values and estimates anatomical labeling using several anatomical labels available for academic use. Please be reminded that we just assemble them for easier access and you have to respect the original developers. So, cite the original articles when you use them.

Appropriate citations are as follows:

AAL(automatic anatomical labeling): Tzourio-Mazoyer, N., Landeau, B., Papathanassiou, D., Crivello, F., Etard, O., Delcroix, N., Mazoyer, B., Joliot, M., 2002. Automated anatomical labeling of activations in SPM using a macroscopic anatomical parcellation of the MNI MRI single-subject brain. NeuroImage 15 (1), 273– 289.

Brodmann area (Chris rorden' MRlcro): Rorden, C., Brett, M., 2000. Stereotaxic display of brain lesions. Behav. Neurol. 12, 191– 200.

LPBA40: Shattuck DW, Mirza M, Adisetiyo V, Hojatkashani C, Salamon G, Narr KL, Poldrack RA, Bilder RM, Toga AW. Construction of a 3D probabilistic atlas of human cortical structures. Neuroimage 2007; 39: 1064-1080.

Brodmann area (Talairach daemon): Lancaster JL, Woldorff MG, Parsons LM, Liotti M, Freitas CS, Rainey L, Kochunov PV, Nickerson D, Mikiten SA, Fox PT. Automated Talairach atlas labels for functional brain mapping. Human Brain Mapping 2000; 10: 120-131.

This function searches the neighbor of a given MNI coordinate positions on the cortical surface. If you define 1cm vicinity, it defines a sphere with a radius of 1cm and accumulates the anatomical labels available within the boundary. The points that have been fallen outside the brain are excluded.

Although these atlases are expressed in the MNI system, they are different. For example, Talairach-based atlases tends to locate the central sulcus more posterior to the other atlases. It is difficult to discern which is the best, but if you are to choose a stable one, AAL tends may be an appropriate one to start with.

It is under modification, so the current status is a bit (lot) user-unfriendly, but it works anyway. Here is how to use the function.

1. Using Matlab, go to “/nfri\_functions” directory.
2. Then, in Command Window, use the function, “nfri\_anatomlabel\_final(input, saveFileName, rn, col)”. Among the augments, *input* is the nx3 or nx4 matrix. The first, second and third columns indicate x, y, and z coordinate values, respectively. If the matrix is nx4, the fourth column indicates SD of each input point.

More often, you may want to use coordinate values stored in an external file. In this case, please store an nx3 or nx4 matrix in an Excel sheet and place it in “/nfri\_functions” directory. In this case, *input* should be a file name enclosed with

a single quotation as 'file name'.

*saveFileName* is any file name of your preference **EXEPT FOR MULTI-BITE CHARACTERS**. The file name should be enclosed with a single citation as 'saveFileName'. The file is stored in */nfri\_functions/* directory.

The augment *rn* indicates the radius of spherical boundary for labeling search.(if matrix is nx4, then *rn* will became fourth column of Input file.) Finally, *col* indicates which atlas is used.

4 ... AAL (Tzourio-Mazoyer N, Neuroimage 15 pp.273-89, 2002)

5 ... Brodmann area (Chris rorden' MRlcro, Rorden C, Brett M. Behav. Neurol. 12, 191– 200, 2000)

6 ... LPBA40 (Shattuck DW et al., Neuroimage 39, 1064-80, 2007)

7 ... Brodmann area (Talairach daemon, Lancaster JL et al. Human Brain Mapping 10, 120-131, 2000.)

For example, type "nfri\_anatomlabel\_final(input, 'XXX',10, 4)", will provide labeling estimation for the MNI coordinates indicated as input file in reference to AAL, and save the anatomical information on XXX file, which is stored in */nfri\_functions/* directory as a csv file.

Default settings for *rn* and *col* are rn=10 and col=4, respectively.

An example file 'sample4nfri\_anatomlable' is stored in */nfri\_functions/* directory. So, please try the following command to see what happens.  
nfri\_anatomlabel\_final('sample4nfri\_anatomlable','Output1',10,5).

## References

For use of this function, in addition to the citation for the specific atlas indicated above, please cite the following reference for acknowledging our efforts.

If you were to choose one, please cite Singh AK et al.

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Thanks in advance.

### **Plotting functional data onto MNI space with “nfri\_mni\_plot” and “nfri\_mni\_plot\_imp”**

The function *nfri\_mni\_plot* is a handy plotter that primarily exhibits cortical activation data onto the MNI-compatible canonical brain. Activation data can be any values such as t-value, F-value, regression coefficient, mean amplitude and so on. They are expressed according to a color scale. The size of plotted channel or probe positions can also be varied. Missing data are exhibited in gray. Out-of-range data can also be expressed wither in black and white.

The function *nfri\_mni\_plot\_imp* is a slightly modified version of *nfri\_mni\_plot*, generating impressionistic drawing of data. The edge of a sphere is blended with background color to yield impressionism-painting-like outlook. It works best with uniform size spheres to be drawn, and usually serves for final data preparation for a conference presentation or journal article. The usage is totally the same as *nfri\_mni\_plot*. However, *nfri\_mni\_plot* is much faster, especially for a large number of channels.

Here is a basic usage for a current version.

1. Prepare an Excel file by referring to an example file called “nfri\_mni\_plot.xls” stored in *sample* folder. The first two rows are used for description. The first column indicates name of the data to be plotted. The second, third and fourth columns indicate x, y, and z coordinate values, respectively. The fifth row represents radius of sphere to be plotted. The fifth column is assigned for intensity of plotted values. The bottom two rows indicated with *MAX* and *MIN* define literary maximum and minimum intensity values to be

plotted. Modify this file to start with.

2. Go to *nfri\_functions* directory in Matlab, and type “*nfri\_mni\_plot*”. For using *nfri\_mni\_plot\_imp*, type “*nfri\_mni\_plot\_imp*”.

3. In a selector window, open *sample* folder, select *nfri\_mni\_plot.xls* file (for example), and open it.

4. In *Automatic scale?* window, choose yes or no. If you choose “yes”, the function searches for the maximum and minimum values and automatically adjust a color scale. If you choose “no”, the function refers to the bottom two rows of the data file and adopt the maximum and minimum values indicated there. Choose “no” for example.

5. In *Color choice* window, choose yes or no. If you choose “yes”, the values above the *max* value is depicted in white, and those below the *min* value, in black. If you choose “no”, the values above the *max* value is depicted in the top most color in the color bar (brown), and those below the *min* value, in the bottom most color in the color bar (deep blue). Choose “yes” for example.

6. You can see a brain spotted with different colors. In this file, the center and radius of each sphere (more like a circle) represents the most likely MNI coordinate point and the composite standard deviation for estimation. If you click toggle label button, data numbers as listed in the original Excel file are shown.

7. Let's play with the other example, and open the file called “*nfri\_mni\_plot\_outlier.xls*”. In this file, some data for intensity values are above *max* or below *min*. In addition, all radius are set to 10 mm. See what happens with the plot.

8. Run *nfri\_mni\_plot* and open the file. Select “no” for *Automatic scale* and “yes” for *Color choice*.

9. As you see, depicted in black are the data with intensity less than *min*, and depicted in white are the data with intensity more than *max*. All the points are shown in the same size.

10. If you need, save the figure using “save figure” button. Insert your

filename, and choose your file format (fig, png, jpeg, bmp).

## References

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Neuroimage. 2005; 27(4):842-51.

PMID: 15979346

Thanks in advance.

## Update history

6/9/2009

Initial version is released.

11/14/2009

1. ReadingM was updated.
2. *nfri\_anatomlabel.m* was replaced with *nfri\_anatomlabel\_final.m* and now works on the main directory, */nfri\_functions*.
3. *nfri\_mni\_plot* and *nfri\_mni\_plot\_imp* was updated.