Anatomical Automatic Labeling (AAL) For SPM8

Version v1

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Anatomical Automatic Labeling (AAL) is a package for the anatomical labeling of

functional brain mapping experiments. It is an in-house package made by

Neurofonctional Imaging Group (GIN, UMR6232, CYCERON, Caen ,France), which is

available to the scientific community as a copyright freeware under the terms of

the GNU General Public Licence.

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I Goal

This project has been initiated in the nineties with the construction of a set

of rules to be used for the anatomical parcellation of the brain according to

major sulci and gyri. We applied this set of rules to built an anatomical

parcellation of the spatially normalized single subject high resolution T1

volume provided by the Montreal Neurological Institute (MNI) (Collins et al.,

1998). The MNI single subject main sulci were first delineated and further used

as landmarks for the 3D definition of 45 Anatomical Volumes Of Interest (AVOI)

in each hemisphere. This procedure was performed using a dedicated software

which allowed a 3D following of the sulci course on the edited brain. Regions of

interest were then drawn manually using the same software every 2 mm on the

axial slices of the high resolution MNI single subject. The 90 AVOI were

reconstructed and assigned a label.

Using this parcellation method, three procedures to perform the automated

anatomical labelling of functional studies are proposed :

1) labelling of an extremum defined by a set of coordinates,

2) percentage of voxels belonging to each of the AVOI intersected by a sphere

centered by an extremum,

3) percentage of voxels belonging to each of the AVOI intersected by an

activated cluster.

An interface with the Statistical Parametric Mapping (SPM8) package (Friston et

al., 1995) is provided as a freeware to researchers of the neuroimaging

community. We believe that this tool is an improvement for the macroscopical

labelling of activated area as compared to labelling assessed using the

Talairach atlas brain in which deformations are well known. However, this tool

does not alleviate the need for more sophisticated labelling strategies based on

anatomical or cytoarchitectonic probabilistic maps.

II Reference

If you need to reference this work, please used the following reference :

Tzourio-Mazoyer N, Landeau B, Papathanassiou D, Crivello F, Etard O, Delcroix N,

et al. Automated anatomical labelling of activations in spm using a macroscopic

anatomical parcellation of the MNI MRI single subject brain. Neuroimage 2002;

15: 273-289.

III Distribution

The distribution includes a readme.txt (this file), 4 parcellation definition

files (the ROI\_MNI\_V4\* files), and 9 program file (\*.m files).

III.1 ROI\_MNI\_V4.img (flat short integer image) and ROI\_MNI\_V4.hdr (header file in

ANALYZE-7 format with slight customizations to the header as described in SPM

help/spm\_format.man and in Neurological Orientation (R is R)). Each anatomical region is

associated a gray level (see III.2).

Note that aal programs manage the orientation of your own analyze image (see defaults.analyze.flip variable).

III.2 ROI\_MNI\_V4\_list.mat : Matlab format file giving the correspondence between the

anatomical region name and the gray level information.

Anatomical-region-name(\*) Gray-level

Precentral\_L 2001

Precentral\_R 2002

Frontal\_Sup\_L 2101

Frontal\_Sup\_R 2102

Frontal\_Sup\_Orb\_L 2111

Frontal\_Sup\_Orb\_R 2112

Frontal\_Mid\_L 2201

Frontal\_Mid\_R 2202

Frontal\_Mid\_Orb\_L 2211

Frontal\_Mid\_Orb\_R 2212

Frontal\_Inf\_Oper\_L 2301

Frontal\_Inf\_Oper\_R 2302

Frontal\_Inf\_Tri\_L 2311

Frontal\_Inf\_Tri\_R 2312

Frontal\_Inf\_Orb\_L 2321

Frontal\_Inf\_Orb\_R 2322

Rolandic\_Oper\_L 2331

Rolandic\_Oper\_R 2332

Supp\_Motor\_Area\_L 2401

Supp\_Motor\_Area\_R 2402

Olfactory\_L 2501

Olfactory\_R 2502

Frontal\_Sup\_Medial\_L 2601

Frontal\_Sup\_Medial\_R 2602

Frontal\_Med\_Orb\_L 2611

Frontal\_Med\_Orb\_R 2612

Rectus\_L 2701

Rectus\_R 2702

Insula\_L 3001

Insula\_R 3002

Cingulum\_Ant\_L 4001

Cingulum\_Ant\_R 4002

Cingulum\_Mid\_L 4011

Cingulum\_Mid\_R 4012

Cingulum\_Post\_L 4021

Cingulum\_Post\_R 4022

Hippocampus\_L 4101

Hippocampus\_R 4102

ParaHippocampal\_L 4111

ParaHippocampal\_R 4112

Amygdala\_L 4201

Amygdala\_R 4202

Calcarine\_L 5001

Calcarine\_R 5002

Cuneus\_L 5011

Cuneus\_R 5012

Lingual\_L 5021

Lingual\_R 5022

Occipital\_Sup\_L 5101

Occipital\_Sup\_R 5102

Occipital\_Mid\_L 5201

Occipital\_Mid\_R 5202

Occipital\_Inf\_L 5301

Occipital\_Inf\_R 5302

Fusiform\_L 5401

Fusiform\_R 5402

Postcentral\_L 6001

Postcentral\_R 6002

Parietal\_Sup\_L 6101

Parietal\_Sup\_R 6102

Parietal\_Inf\_L 6201

Parietal\_Inf\_R 6202

SupraMarginal\_L 6211

SupraMarginal\_R 6212

Angular\_L 6221

Angular\_R 6222

Precuneus\_L 6301

Precuneus\_R 6302

Paracentral\_Lobule\_L 6401

Paracentral\_Lobule\_R 6402

Caudate\_L 7001

Caudate\_R 7002

Putamen\_L 7011

Putamen\_R 7012

Pallidum\_L 7021

Pallidum\_R 7022

Thalamus\_L 7101

Thalamus\_R 7102

Heschl\_L 8101

Heschl\_R 8102

Temporal\_Sup\_L 8111

Temporal\_Sup\_R 8112

Temporal\_Pole\_Sup\_L 8121

Temporal\_Pole\_Sup\_R 8122

Temporal\_Mid\_L 8201

Temporal\_Mid\_R 8202

Temporal\_Pole\_Mid\_L 8211

Temporal\_Pole\_Mid\_R 8212

Temporal\_Inf\_L 8301

Temporal\_Inf\_R 8302

Cerebelum\_Crus1\_L 9001

Cerebelum\_Crus1\_R 9002

Cerebelum\_Crus2\_L 9011

Cerebelum\_Crus2\_R 9012

Cerebelum\_3\_L 9021

Cerebelum\_3\_R 9022

Cerebelum\_4\_5\_L 9031

Cerebelum\_4\_5\_R 9032

Cerebelum\_6\_L 9041

Cerebelum\_6\_R 9042

Cerebelum\_7b\_L 9051

Cerebelum\_7b\_R 9052

Cerebelum\_8\_L 9061

Cerebelum\_8\_R 9062

Cerebelum\_9\_L 9071

Cerebelum\_9\_R 9072

Cerebelum\_10\_L 9081

Cerebelum\_10\_R 9082

Vermis\_1\_2 9100

Vermis\_3 9110

Vermis\_4\_5 9120

Vermis\_6 9130

Vermis\_7 9140

Vermis\_8 9150

Vermis\_9 9160

Vermis\_10 9170

(\*) Note that the cerebral AVOI definitions are fully described in the paper by

Tzourio-Mazoyer et al. (Tzourio-Mazoyer et al., 2002). The cerebellar AVOI

definitions are based on the cerebellum parcellation proposed by Schmahmann et

al. (Schmahmann et al., 1999).

III.3 ROI\_MNI\_V4\_Border.mat : Matlab format file listing the border of each region.

This file is used in the automatic labeling procedure.

III.4 the matlab program files :

aal.m

gin\_clusters.m

gin\_clusters\_plabels.m

gin\_det\_dlabels.m

gin\_det\_plabels.m

gin\_dlabels.m

gin\_list\_dlabels.m

gin\_list\_plabels.m

gin\_rclusters.m

IV How to install the software.

Note that aal procedures have been tested only on unix machines.

IV.1 Copy the archive to the chosen location

In this example we choose to install the software directly at the same location

than the spm distribution (/usr/local/soft/spm8/toolbox)

unix> cp aal\_for\_spm8.tar.Z /usr/local/soft/spm8/toolbox

unix> cd /usr/local/soft/spm8/toolbox

IV.2 Expand the archive will create an anat\_aal\_vb1 directory

unix> uncompress aal\_for\_spm8.tar.Z

unix> tar xvf aal\_for\_spm8.tar

IV.3 Add this directory to your matlab path

unix > setenv MATLABPATH ${MATLABPATH}:/usr/local/soft/spm8/toolbox/aal

V How to use the software.

V.1 Do a regular statistical analysis using spm8

V.2 Launch matlab

unix > matlab

V.3 launch aal

>> aal

V.4 Choose a labeling procedure. The 3 choices are explained and documented in

the Neuroimage paper (Tzourio-Mazoyer et al., 2002):

Local maxima labeling

Extended local maxima labeling

Cluster labeling

V.5 Select the desired contrast, mask, probability and extent threshold like in

the regular spm\_result

V.6 For "Extended local maxima labeling" input the local maxima radius of the

sphere in millimeters (default 10 mm).

V.7 Select the anatomical parcellation database :

In /usr/local/soft/spm8/toolbox/aal

The file ROI\_MNI\_V4.nii

V.8 Results

V.8.1 Local maxima labeling

For each local maxima :

-coordinates in mm x,y,z

-anatomical label (see below)

-distance in millimeter to this region. If the local maxima is inside a region

this distance is null (0.00). If the local maxima is outside the parcellation

the nearest region name is displayed in the previous column and the shortest

distance from the local maxima to this region is listed (exp : 2.30 mm)

-anatomical label of the local maxima to the second nearest region

-shortest distance of the local maxima to the second nearest region

-anatomical label of the local maxima to the third nearest region

-shortest distance of the local maxima to the third nearest region

V.8.2 Extended local maxima labeling

Each local maxima is supposed to be a 10 mm (if the default is used) spherical

region. The intersection of this volume and the AVOI is computed and the result

sorted in a descending order according the percentage of overlap (exp : a result

of Postcentral\_L 100 % indicates that the 10mm radius region surrouding the

local maxima is fully included in the Postcentral\_L region)

For each local maxima :

-coordinates in mm x,y,z

-list of anatomical label and percentage of overlap. Percentage less than 1% are

not listed. If part of the region is outside the parcellation the anatomical

label will list "OUTSIDE".

V.8.3 Cluster labeling

The intersection of each cluster and the AVOI is computed and the result sorted

in a descending order according the percentage of overlap.

For each local maxima :

-coordinates in mm x,y,z of the most significative local maxima of the cluster

-list of anatomical label and percentage of overlap. Percentage less than 1% are

not listed. If part of the region is outside the parcellation the anatomical

label will list "OUTSIDE".

Example : a result of

-44 -22 - 56 Postcentral\_L 55.00

Precentral\_L 31.00

OUTSIDE 10.00

Parietal\_Sup\_L 5.00

indicates that :

55% of the cluster volume is included in the Postcentral\_L region

31% of the cluster volume is included in the Precentral\_L region

10% of the cluster volume is outside the parcellation

5% of the cluster volume is included in the Parietal\_Sup\_L region

VI Bibliography

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et al. Automated anatomical labelling of activations in spm using a macroscopic

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VII Contact

Any comments could be send to aalgin@cyceron.fr.

VIII History

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