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ABSORB: Atlas Building by Self-Organized Registration and Bundling

Hongjun Jia, Guorong Wu, Qian Wang and Dinggang Shen

Image Display, Enhancement, and Analysis (IDEA) Laboratory
Department of Radiology and Biomedical Research Imaging Center (BRIC)
University of North Carolina at Chapel Hill, Chapel Hill, NC 27599

1. Purpose

This software package implements ABSORB: Atlas Building by Self-Organized Registration and Bundling [1,2] – an algorithm for effective groupwise registration, which is published as:

Hongjun Jia, Guorong Wu, Qian Wang, Dinggang Shen, "ABSORB: Atlas Building by Self-Organized Registration and Bundling", NeuroImage, Vol. 51, No. 3, 1 July 2010, pp. 1057-1070.

The package is available free to the public for the academic research purpose at IDEA lab webpage <http://bric.unc.edu/ideagroup/free-softwares/>, and NITRC <http://www.nitrc.org/projects/absorb>.

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2. System and Installation

This software is developed using ITK (<http://www.itk.org/>) and has been tested on Windows XP (32-bit) and Linux (64-bit, kernel version 2.6.18-194.el5). The required input is a set of 3D MR intensity images (in Analyze format with paired .hdr and .img files) with a text file (.txt) listing all header files (.hdr) names. The output is the set of registered images together with the corresponding dense deformation fields. The following is the software packages required by ABSORB.

2.1. Affinity propagation

ABSORB uses Affinity Propagation (*Frey and Dueck, Clustering by Passing Messages Between Data Points, Science 315, 972–976, Feb. 2007*) for clustering in the image bundling stage.

To download the relevant libraries, please use the following link:

<http://www.psi.toronto.edu/index.php?q=affinity%20propagation>

Only apclusterwin.dll or apclusterunix64.so is needed. For convenience, we have included them with the package.

2.2. Diffeomorphic demons

ABSORB uses Diffeomorphic demons (*Vercauteren et al., Diffeomorphic demons: Efficient non-parametric image registration, Neuroimage, 45(1 Suppl):S61-72, 2009*) as the registration engine for estimating the dense deformation field between a set of 3D MR intensity images. Please refer to the following websites for the code and the paper:

<http://insight-journal.org/browse/publication/154>

<http://www.ncbi.nlm.nih.gov/pubmed/19041946>

2.3. Tcl/Tk

ABSORB GUI version uses Tcl/Tk 8.5 version (<http://www.tcl.tk/software/tcltk/>) together with KWWidgets (<http://www.kwwidgets.com/>) and VTK (<http://www.vtk.org/>). Please have Tcl/Tk installed on your Linux 64-bit system, or copy the lib folder and the library files tcl85.dll, tk85.dll in the package to the same folder as other executable files on your Windows XP 32-bit system.

2.4. C runtime library in Windows

If the pop-up windows shows the error information as “This application has failed to start because the application configuration is incorrect”, please download and install Microsoft Visual C++ 2005 Redistributable Package (x86) (<http://www.microsoft.com/downloads>) if you do not have Visual C++ 2005 installed on your machine with Windows. You can also use the file vcredist_x86.exe, which is included in this package, to install.

2.5. Download package

Package for Windows-32bit includes:

- ABSORB_GUI_main.exe, ABSORB_command.exe, apclusterwin.dll,
- MSVCP80.dll, MSVCR80.dll, MSVCM80.dll, Microsoft.VC80.CRT.manifest, vcredist_x86.exe,
- tcl85.dll, tk85.dll, and a tcl/tk library folder: lib
- ApplyDeformationField.exe

Package for Linux-64bit includes:

- ABSORB_GUI_main, ABSORB_command, apclusterunix64.so
- ApplyDeformationField

2.6. Before starting ABSORB

All MR intensity images used as inputs to ABSORB should be pre-processed so that they are in the same situation (i.e., skull-stripped or not, cerebellum removed or not, etc.). And all input images should be in Analyze format with paired header (.hdr) and image (.img) files.

- Please copy all program files, library files and lib folder (for windows) in the package to a same folder.
- Please create a text file (.txt) within the data folder, which includes all header file names (one per line). This is the image list file as the only required input of ABSORB.
- Please make sure that there are NOT any spaces in the absolute path of the image list file. For example, do not copy data files to the desktop in windows, as its path, "Documents and Settings," includes spaces.

3. The ABSORB GUI

3.1. User interface

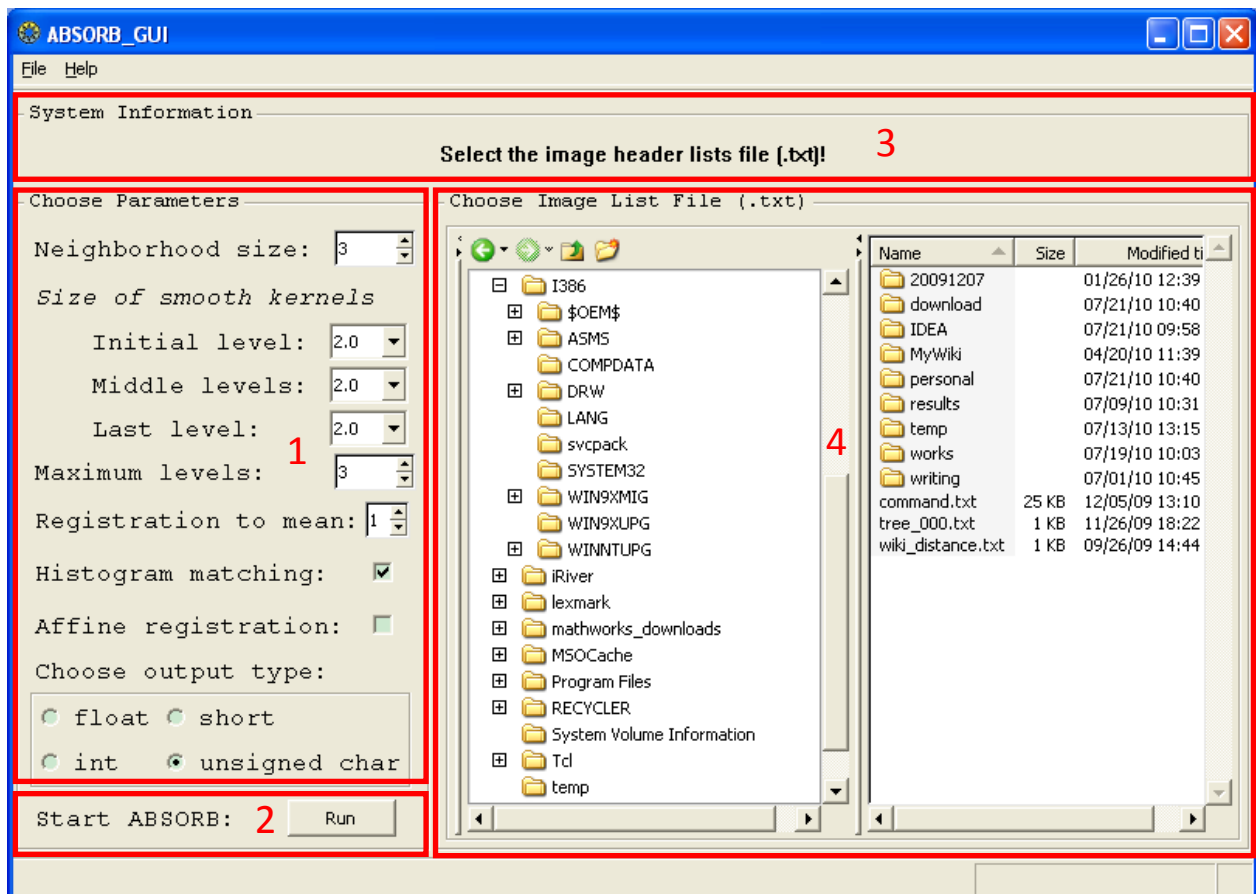
The GUI can be launched by calling:

```
ABSORB_GUI_main
```

The GUI is divided into several regions:

- Region 1: Parameters used by ABSORB
- Region 2: Button to start ABSORB
- Region 3: System information
- Region 4: Panel for selecting the list file

The detailed explanation for each region is given below.



3.2. Required Parameters

Some key parameters are explained as follows. Please note that the optimal parameters may vary depending on applications.

Neighborhood size: An integer between 3 and 5 (default is 3), the number of nearest neighboring images to be considered in the self-organized registration step.

Size of smoothing kernels: A number between 1.0 and 3.0 (default is 2.0) which is used for the parameter $-s$ of the Diffeomorphic demons algorithm (see Diffeomorphic demons for details). In the initial level, this parameter is usually set to a relatively large value (e.g., 2.0 ~ 3.0), which is gradually decreased in the middle (e.g., 1.5 ~ 2.5) and final (e.g., 1.0 ~ 2.0) levels.

Maximum number of levels: Controls the number of levels for the constructed hierarchical structure during the registration, which takes a value between 3 and 5 (default is 3).

Registration to mean: A number between 0 and 3 (default is 1), which is the number of additional runs of registering all images to the mean image at the end of ABSORB.

Histogram Matching: Set whether histogram matching is performed before each pairwise registration. This is usually set to true when dealing with real brain images, and false for synthetic data.

Affine registration: Set whether the affine registration is performed before the non-rigid groupwise registration.

Output data type: Select the data type for the registered images among FLOAT (32-bit real), INT (32-bit integer), SHORT (16-bit integer) and UCHAR (8-bit unsigned char, default).

3.3. File List

All the header file (.hdr) names are listed in one single text file (.txt) - one file name per line, which is one of the inputs to ABSORB. Please make sure that all .hdr files and their corresponding .img files exist in the same folder as well as the list file. Please notice that there should NOT be any space in the data folder name or any parent/ancestor folders' name. For example, do not copy data files to the desktop in windows as its path, "Documents and Settings," includes spaces.

The first image will be selected as the template for preprocessing steps (e.g., affine registration and image resizing) when preparing the files for registration. The image file names can NOT be like AA_cbq_000.hdr (.img), which will be used as internal file names. An example of the list file is as follows:

```
Image1.hdr  
Image2.hdr  
Image3.hdr  
Image4.hdr  
Image5.hdr  
Image6.hdr  
Image7.hdr  
Image8.hdr
```

The first image file listed in the file list will be selected to serve as the template for affine registration if Affine Registration is set, and as the standard for resizing if not all the images are with the same size or resolution. This first image file is selected up to the user if they believe the affine registration or resizing is necessary for the data.

3.4. Starting ABSORB

Before running ABSORB, copy all executable files and the library file in the package to a same folder.

For 32-bit windows, these files are:

- ABSORB_GUI_main.exe, ABSORB_command.exe, apclusterwin.dll, tcl85.dll, tk85.dll and the lib folder.

For 64-bit Linux, these files are:

- ABSORB_GUI_main, ABSORB_command, and apclusterunix64.so.

One can start to run ABSORB GUI version from the folder with all image files and image list file by calling ABSORB_GUI_main. If all parameters are properly set and the list file is selected, ABSORB can start by pressing the button "Run".

3.5. Result

All images will be first affinely registered (if Affine Registration is set) to the first image in the list file, with proper resizing, and then a series of intermediate files AA_cbq_000.hdr (.img), AB_cbq_000.hdr (.img), ..., are created with their respective affine transformation parameters stored in AA_affine.txt, AB_affine.txt, They are generated with the same size, resolution and data type. If resizing is performed as not all images are of the same size, a series of images with name (e.g., Image1_res.hdr and Image1_res.img) are also generated. The first two characters in the file names are the subject ID used internally in ABSORB (from AA to ZZ to represent a maximum of 26*26 images) and the last three digits are the iteration index. If Affine Registration is not set, the affine parameter file stores the information of an identity transformation.

Then, ABSORB performs deformable registration based on the input parameters. The outputs of iteration “xxx” for each subject ID (e.g., AA) are AA_cbq_xxx.hdr and AA_cbq_xxx.img (the deformed image), AA_deform_xxx.mha (the dense deformation field).

Finally, once ABSORB is done, the registered images will be renamed based on their original names, e.g., Image1_reg.hdr and Image1.img) for the registered image and Image1_reg.mha for the final dense deformation field. The average image of all registered images is also given with the name as mean_output_reg.hdr and mean_output_reg.img).

A typical list of the input/output files is as follows.

Program files		Input files	Output files
32-bit Windows	64-bit Linux		
ABSORB_GUI_main.exe ABSORB_command.exe apclusterwin.dll	ABSORB_GUI_main ABSORB_command apclusterunix64.so	filelists.txt Image1.hdr(img) Image2.hdr(img) Image3.hdr(img) Image4.hdr(img) Image5.hdr(img) Image6.hdr(img) Image7.hdr(img) Image8.hdr(img)	Image1_reg.hdr(img, mha) Image2_reg.hdr(img, mha) Image3_reg.hdr(img, mha) Image4_reg.hdr(img, mha) Image5_reg.hdr(img, mha) Image6_reg.hdr(img, mha) Image7_reg.hdr(img, mha) Image8_reg.hdr(img, mha) Mean_output_reg.hdr(img)

3.6. System Information

Select the image header lists file (.txt)!

Initial information.

Please select one file with image names!

If zero or more than one files is selected in the file explorer window.

Please check all .hdr and .img files!

If the image file sanity check is not successful. Possible causes include: 1) some file names do not have the extension hdr, 2) missing header (.hdr) files, 3) missing image (.img) files.

Missing library file apclusterwin.dll.

If the required library file is not found within the same folder as ABSORB_GUI_main.exe.

Missing executable file ABSORB_command.exe.

If the required executable file is not found within the same folder as ABSORB_GUI_main.exe.

Spaces found in the data file path!

If any space is found in the absolute path of data or image list files.

Missing filelist file.

If the image list file is not found.

ABSORB is running ...

If ABSORB starts normally.

ABSORB failed!

If ABSORB failed for some reason.

ABSORB is done successfully!

If ABSORB is successfully executed.

4. Command Line Version

The command line version of ABSORB, `ABSORB_command`, is similar to the GUI version. Please make sure that the executable file, `ABSORB_command.exe` for 32-bit windows or (`ABSORB_command` for 64-bit Linux and the library file (`apclusterwin.dll` for 32-bit windows or `apclusterunix64.so` for 64-bit Linux) are in the same folder. Create a text file listing all image header file names in the data folder and start ABSORB with `ABSORB_command`.

A typical call is as follows.

```
ABSORB_command -f filelists.txt -n 3 -i 2.0 -m 1.5 -l 1.5 -p 4 -g 2 -d 1 -a 0  
-t UCHAR
```

Parameters are listed below (option `-f` is required).

Command tags:

```
-f --image-file-list < filename >  
  = text file (.txt) listing all header file (.hdr) names,  
  one per line  
[ -n --k-nearest-neighbor < intval > ]  
  = number of nearest neighbors to search (3~5)  
  With: intval (Default = 3)  
[ -i --sigma-init < floatval > ]  
  = Deformation field smoothing kernel for initial level (1.0~3.0)  
  With: floatval (Default = 2.0)  
[ -m --sigma-mid < floatval > ]  
  = Deformation field smoothing kernel for middle levels (1.0~3.0)  
  With: floatval (Default = 2.0)  
[ -l --sigma-last < floatval > ]  
  = Deformation field smoothing kernel for last level (1.0~3.0)  
  With: floatval (Default = 2.0)  
[ -p --level-max < intval > ]  
  = maximum number of levels in the built pyramid (3~5)  
  With: intval (Default = 3)  
[ -g --run-group-mean < intval > ]  
  = additional runs of registration to group mean (0~3)  
  With: intval (Default = 1)  
[ -d --do-histogram-match < intval > ]  
  = do histogram matching or not before registration,  
  0 for no and all otherwise for yes  
  With: intval (Default = 1)  
[ -a --do-affine-registration < intval > ]  
  = do affine registration or not before non-rigid groupwise registration,  
  0 for no and all otherwise for yes  
  With: intval (Default = 0)  
[ -t --output-type < type > ]  
  = set the output type to FLOAT, INT, SHORT or UCHAR  
  With: type (Default = UCHAR)
```

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Code: Hongjun Jia

Report bugs to <jiahj \at med.unc.edu>

Refer to ABSORB: Atlas Building by Self-Organized Registration and Bundling,
in NeuroImage, Vol. 51, No. 3, 1 July 2010, pp. 1057-1070.

5. Miscellaneous

5.1. Warping Images Using the Estimated Deformation Fields

`ApplyDeformationField` can be used to apply a dense deformation field on an image and generate the deformed image. Set the last parameter (`isLinear`) to 0 for nearest neighbor interpolation (e.g., for warping a segmentation label image) or 1 for linear interpolation (e.g., for warping intensity images).

```
Usage: ApplyDeformationField  
      DeformationFieldFileName[.mha] MovingImageFileName[.hdr]  
      [DeformedImageName:output.hdr] [isLinear:1]
```

Please note, if the resizing step is performed before registration when not all images are of the same size or resolution, the output deformation field may not be applied on the original input intensity images or the corresponding segmentation images.

6. References

[1] Hongjun Jia, Guorong Wu, Qian Wang, Dinggang Shen, "ABSORB: Atlas Building by Self-Organized Registration and Bundling", *NeuroImage*, Vol. 51, No. 3, 1 July 2010, pp. 1057-1070.

[2] Hongjun Jia, Guorong Wu, Qian Wang, Dinggang Shen, "ABSORB: Atlas Building by Self-Organized Registration and Bundling", in *Proc. of the 23rd IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2010)*, San Francisco, CA, 2010.

7. Contact us

For any questions or bug reports, please email jiahj@med.unc.edu.