Further author information: (Send correspondence to J.C.P)
J.C.P.: E-mail: jprieto@med.unc.edu
D.P: E-mail:danaele@email.unc.edu
M.S.: styner@cs.unc.edu

CIVILITY: Cloud based Interactive Visualization of Tractography Brain Connectome

Danaële Puechmaille.a, Juan C. Prieto.a and Martin Stynera aNeuro Imaging Reasearch and
University of North Carolina, Chapel Hill, North Carolina

July 6, 2016

Abstract

We propose a new tool named Cloub based Interactive Visualization of Tractography Brain Connectome (CIVILITY) which is an interactive visualization tool of brain connectome in the web. CIVILITY is a web application and has mainly 2 components.

- CIVILITY-visualization ; front end of the application. This is a circle plot of the brain connectivity using the method of visualization : Hierarchical Edge Bundling. The graphic visualization of the brain connectivity is generated using Data Driven Documents (D3.js) [1].

- CIVILITY-tractography ; analysis pipeline. The analysis of the brain connectome is computed with a probabilistic tractography method (FSL tools : bepostx and probtrackx2) using surfaces as seeds. Seeds surfaces are created with the ExtractLabelSurfaces [2].

CIVILITY performs the brain connectivity analysis in remote computing grids where the CIVILITY-tractography pipeline is deployed. CIVILITY uses clusterpost [3] to submit the jobs to the computing grid. Clusterpost is a server application providing a REST api to submit jobs in remote computing grids using. Data transfer, job execution and monitoring are all handled by clusterpost. The front end of CIVILITY submits tasks to clusterpost and retrieves results when they are finished. This work is motivated by medical applications in which brain connectivities need to be compute automatically and analyzed easily.

This paper is submitted to the SPIE Medical Imaging 2016 conference in the category Image processing.

Tractography, connectivity, diffusion tensor imaging, atlas, visualization, brain connectome, open source software, cloud

[1] https://github.com/d3/d3

[2] https://github.com/NIRALUser/ExtractLabelSurfaces

[3] https://github.com/NIRALUser/clusterpost

1 INTRODUCTION

Tractography has found many applications over the past decade. Some applications include neurosurgical planning; assessment and study of neurological diseases such as multiple sclerosis or schizophrenia; and post-surgical validation. However the analyze of the connectivity matrix is not intuitive and easy to interpret. That's why this application offer to researchers an interactive web interface to show the connectivity clearly according to some parameters.

In this paper, we present CIVILITY, an open source web application hosted in a cloud. This tool offer to researchers the possibility to launch an unique tractography script and the visualize the brain connectome interactively. Each user is identifying by an user account associated with privileges and can access to his results from anywhere in the cloud. The tractography pipeline uses the probabilistic method of tractography [4] using surfaces as seeds (FSL tools : bedpostx and probtrackx). User must upload data (all of them must be in the same space : diffusion space) and set tractography parameters in the tractography form. The tractography pipeline is executed on the computing grid and once is finished results are retrieved and brain connectome visualization is possible. The graphic visualization of the brain connectome is generated using Data Driven Documents (D3.js) and more precisely the method Hierarchical Edge Bundling. This is a circle plotting representing the brain connectivity. All links can be threshold between two values, their shape can also be modified for an easier visualization. This tool is submitted at the SPIE Medical Imaging 2016 conference in the category Image processing and we seek to enable further clinical and research applications of tractography.

In summary, CIVILITY performs tractography by sending jobs in remote computing grid using the tool clusterpost. Once the tractography is finished, results are retrived and the brain connectome is visualized interactively In order to validate this pipeline and show visualization results, we applied the tractography pipeline to a dataset and retrieves results for using the visualization

The following section explains in detail the methods used in CIVILITY.

2 METHODS

This section explains in detail the two components of CIVILITY : tractography and visualization.

2.1 Tractography

2.1.1 Tractography form

First, a tractography form is used to upload data and set tractography parameters. All data required for the tractography must be already been registered in the same space : DWI space. The images to provide are : Diffusion weighted

[4] describe all possible trajectories

imaging (DWI), T1 reference image, brainmask and must be in the NRRD format. The tractography pipeline uses the probabilistic method of tractography using surfaces as seeds, thus a brain surface representing the white matter must be upload. The surface to provide must be a VTK file and must contain label information (and must be also in DWI space). If there isn't label information, another VTK surface, with the same mesh and containing labels, must be upload. The name of the labelset in the VTK file must be known and specified to the tractography form. All label are identify by an ID, it is possible to ignore a ROI in the tractography by setting the label ID in the form. In addition, a JSON file must be upload. This file describe the parcellation table: seeds names, labels id, matrix order, etc.). As explained before, the tratography uses FSL tools : bedpostx and probtrackx. The number of tensors in the voxel fitting is set to 2 by default, but can be modified by the user.

2.1.2 Tractography pipeline

In this section the pipeline is describe.

First, The tool DWIConvert [5] is used to convert nrrd to nifti images, this last format is required to use FSL tools in tractography. Then, bedpostx tool is used to build default distributions of diffusion parameters at each voxel. The tractography is using surfaces as seeds. The tool ExtractLabelSurfaces is extracting label surfaces (ASCII format) from the White Matter surface (VTK file). From surfaces created a seed list is created (file containing list of path of the seeds surfaces).

Probtrackx2 is the probabilistic tractography, it run on the output of bedpostX and according to a seed list. The seed list is created according to the atlas describe in the json file. Each seeds are label surfaces. These surfaces are created with the C++ tool : ExtractLabelSurfaces apply on the vtk brain surface containing labels. The label extraction can used overlapping or not. The tractography results is a connectivity matrix. Once the tractography done, CIVILITY allow users to visualize easily the connectivity matrix like explain in the following section.

The entire pipeline is available in the github project repository.

2.2 Visualization

2.2.1 Matrix Computation

CIVILITY-visualization is the front end of the application. The brain connectome can be visualized using results from the tractography compute in the computing grinds

Tractography results are shown in a summary jobs table. For each jobs, the job status is print and when a job is done, an interactive plotting is available. The matrix is first normalized by the number of fiber per rows. The circle plot show a triangular matrix computed by the maximum, minimum or average

[5] https://github.com/BRAINSia/BRAINSTools/tree/master/DWIConvert

between upper and lower triangular matrix according to the user selection in the web interface. The brain connectivity can also be threshold. The shape of connectivity matrix can be modify for a better visualization.

2.2.2 Visualization parameters

The following section describe materials used in CIVILITY.

3 MATERIALS

We apply our tractography pipeline to 19 infants (scanned at 1 year and 2 years approximately). All data had previously been QC and registered in the same space : DWI space. The Middle surface is containing labels information according to the brain atlas AAL90.

The following section shows the results of this pipeline.

4 RESULTS

Tractography 1year / 2year

Average Variability Main differents 1y/2y – time of computation – Results Matrix result / matrix computation / visualization

5 CONCLUSIONS

We presented CIVILITY,

Thanks to Dr. Guilmore, UNC, for use of his dataset. Grants: UO1MH070890, U54HDO79124, RO1MH091351.