Baby Brain Toolkit

Fbrain ERC project: Computational Anatomy of Fetal Brain

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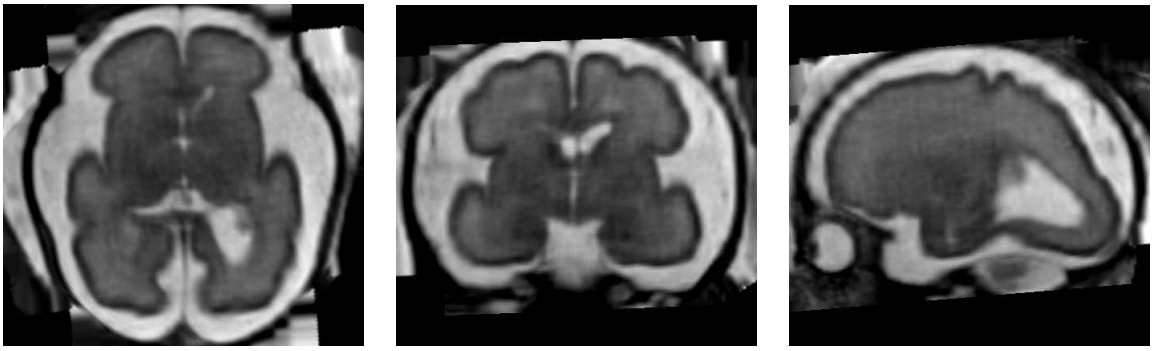
Contents

1 Introduction

BTK stands for Baby Brain Toolkit. This toolkit is developed in the context of the Fbrain ERC project: "Computational Anatomy of Fetal Brain"[1]. Studies about brain maturation aim at providing a better understanding of brain development and links between brain changes and cognitive development. Such studies are of great interest for diagnosis help and clinical course of development and treatment of illnesses. Several teams have begun to make 3D maps of developing brain structures from children to young adults. However, working out the development of fetal and neonatal brain remains an open issue. This project aims at jumping over several theoretical and practical barriers and at going beyond the formal description of the brain maturation thanks to the development of a realistic numerical model of brain aging.

1.1 Copyright

[1] http://lsiit-miv.u-strasbg.fr/miv/index.php?contenu=erc



(a) (b) (c)

Figure 1: Example of an anatomical reconstruction of a fetal brain by using `btkImageReconstruction`. (a) axial, (b) coronal, and (c) sagital view.

1.2 Dependencies and Compilation

Baby Brain Toolkit (BTK) depends on:

- The most recent version of the Insight ToolKit (ITK) – www.itk.org.
- Tclap library: this library can be installed for debian-based distribution using the following command line : `apt-get install libtclap-dev`
- OpenMP library: this library can be installed for debian-based distribution using the following command line : `apt-get install libgomp1`

2 Applications

2.1 Denoising

btkNLMDenoising This program applies a non-local mean filter to a 3D image for denoising purpose. Usage: `-i input_image_filename -o output_image_filename`. The best results are usually obtained by using a mask (or a padding value).

btkNLMDenoising4DImage This program applies a non-local mean filter to each 3D image of a 4D image, for denoising purpose. Usage: `-i input_image_filename -o output_image_filename`. The best results are usually obtained by using a mask (or a padding value).

2.2 Anatomical reconstruction

btkImageReconstruction This program allows to obtain a high-resolution image from a set of low-resolution images, typically axial, coronal, and sagital acquisitions [1].

Minimal usage: `btkImageReconstruction -i image1 ··· -i imageN -o output`.

Recommended usage: `btkImageReconstruction -i image1 ··· -i imageN -m mask1 ··· -m maskN -o output --mask`. The use of a mask provide better results since it allows an accuratelly estimation of the initial transform, and constrains the registration to the region of interest.

The full list of optional parameters of the method can be obtained by `btkImageReconstruction --help`

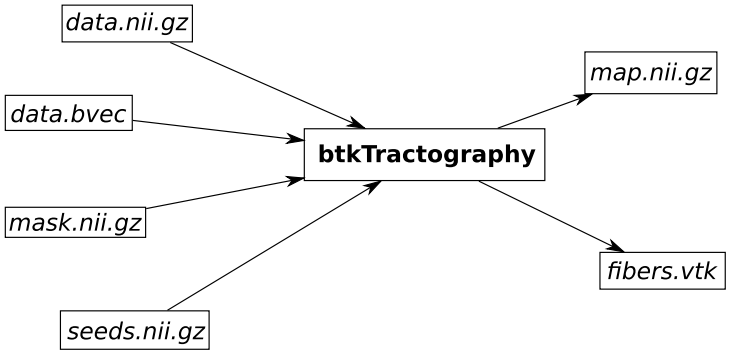


Figure 2: Standard pipeline of the btkTractography program.

Table 1: test

Action	modify model's order (`i.e.` spherical harmonics order)
Default	4
Command	`--model-order <n>` `n`$\in \{2, 4, 6, 8\}$

2.3 Tractography

Standard usage

Suppose you want to perform a tractography on a diffusion weighted MRI dataset. You should have a dwi image, the corresponding gradient vectors' coordinates, a mask of the brain white matter and a label image of the seeds. Assume this data is stored in files named repsectively for instance `data.nii.gz`, `data.bvec`, `mask.nii.gz` and `seeds.nii.gz`. The tractography is accomplished by the command below.

```
btkTractography -d data.nii.gz -v data.bvec -m mask.nii.gz -l seeds.nii.gz
```

When the program terminates its task, the probability connection map and the fibers estimation are saved in files respectively named `map.nii.gz` and `fibers.vtk`. The connection map is a volume image of probability intensities (`i.e.` intensities between 0 and 1) with the same origin, orientation and spacing as the diffusion weighted image. The fibers are polygonal data of VTK library in world coordinates. The standard pipeline of the program is shown in Fig. 2.

Advanced usage

In addition to standard arguments of `btkTractography` program, there are some other parameters that let you to alter algorithm's behaviour. Since the default parameters values may work in the most of cases, they are optional. A list is of optional features is avaible by using the command

```
btkTractography --help
```

and program's arguments are much more described below.

Model's order

Model's regularization

Action	modify the regularization coefficient of the model estimation
Effect	reduce estimation errors
Default	0.006
Command	`--model-regularization <r>` `r`$\in \mathbb{R}$

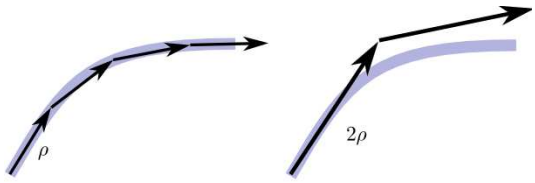


Figure 3:

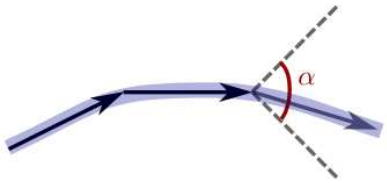


Figure 4:

Displacement step size

Action	modify the displacement length of the particles in voxels
Effect	control the displacement speed of the particles
Default	0.5
Command	`--step-size <r>` `r`$\in \mathbb{R}_+^*$

Angular threshold

Action	modify the maximal angle in radians between two successive vectors
Effect	constraint the curvature *a priori* of the estimated fibers
Default	$\pi/3$
Command	`--angular-threshold <a>` `a`$\in]0, 2\pi[$

Rigidity

Action	modify the concentration of the VMF use in the *prior* density
Effect	constraint the rigidity *a priori* of the estimated fibers
Default	30
Command	`--curve-constraint <r>` `r`$\in \mathbb{R}_+^*$

Number of particles

Action	modify the number of particles in th system
Effect	control the algorithm's precision
Default	1000
Command	`--number-of-particles <n>` `n`$\in \mathbb{N}^*$

Figure 5:

Resampling threshold

Action	modify the effective sampling threshold (in %)
Effect	control the particles with a low weight
Default	0.6
Command	`--resampling-threshold <r>` `r`$\in [0, 1]$

3 Utilities

btkModifyImageUsingLookUpTable This program modifies one image using a look up table defined in a ascii file (2 columns, one for the original values, one for the final values). Usage: `-i input_image_filename -t input_table_filename -o output_image_filename`

Acknowledgment

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References

[1] Francois Rousseau, Orit A Glenn, Bistra Iordanova, Claudia Rodriguez-Carranza, Daniel B Vigneron, James A Barkovich, and Colin Studholme. Registration-based approach for reconstruction of high-resolution in utero fetal MR brain images. *Acad Radiol*, 13(9):1072–1081, Sep 2006.