



HAL
open science

Connectivity directionally-encoded color map: a streamline-based color mapping

Gabriel Girard, Kevin Whittingstall, Rachid Deriche, Maxime Descoteaux

► To cite this version:

Gabriel Girard, Kevin Whittingstall, Rachid Deriche, Maxime Descoteaux. Connectivity directionally-encoded color map: a streamline-based color mapping. The Organization for Human Brain Mapping (OHBM), Jun 2014, Hambourg, Germany. hal-01103640

HAL Id: hal-01103640

<https://hal.science/hal-01103640>

Submitted on 15 Jan 2015

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Connectivity directionally-encoded color map: a streamline-based color mapping

Submission Number:

556

Authors:Gabriel Girard^{1,2}, Kevin Whittingstall¹, Rachid Deriche², Maxime Descoteaux¹**Institutions:**¹Université de Sherbrooke, Sherbrooke, Qc, Canada, ²INRIA, Sophia-Antipolis, France**First Author:**

Gabriel Girard - Lecture Information | Contact Me
Université de Sherbrooke|INRIA
Sherbrooke, Qc, Canada|Sophia-Antipolis, France

Introduction:

Diffusion-weighted (DW) magnetic resonance imaging (MRI) and tractography are used to reconstruct white matter (WM) pathways between brain regions. A growing number of studies exploit structural properties of these pathways or streamlines to infer structural connectivity between areas (Hagmann et al., 2008, Pannek et al., 2011, Fornito et al., 2013). Thus, it is of interest to develop new tools to visualize these properties. In a similar fashion as in (Calamante et al., 2012, Pannek et al., 2011), we are interested in the properties of streamlines intersecting a three dimensional grid. In (Calamante et al., 2012) the authors proposed the method directionally-encoded color Track-Weighted Imaging (DEC-TWI) which represents the average orientations of segments of streamlines going through each voxel. In (Pannek et al., 2011), the authors proposed the method Average Pathlength Map (APM), that generates a scalar map of the average length of streamlines intersecting each voxel. In this study, we propose a novel orientation color-coded map based on streamline tractography.

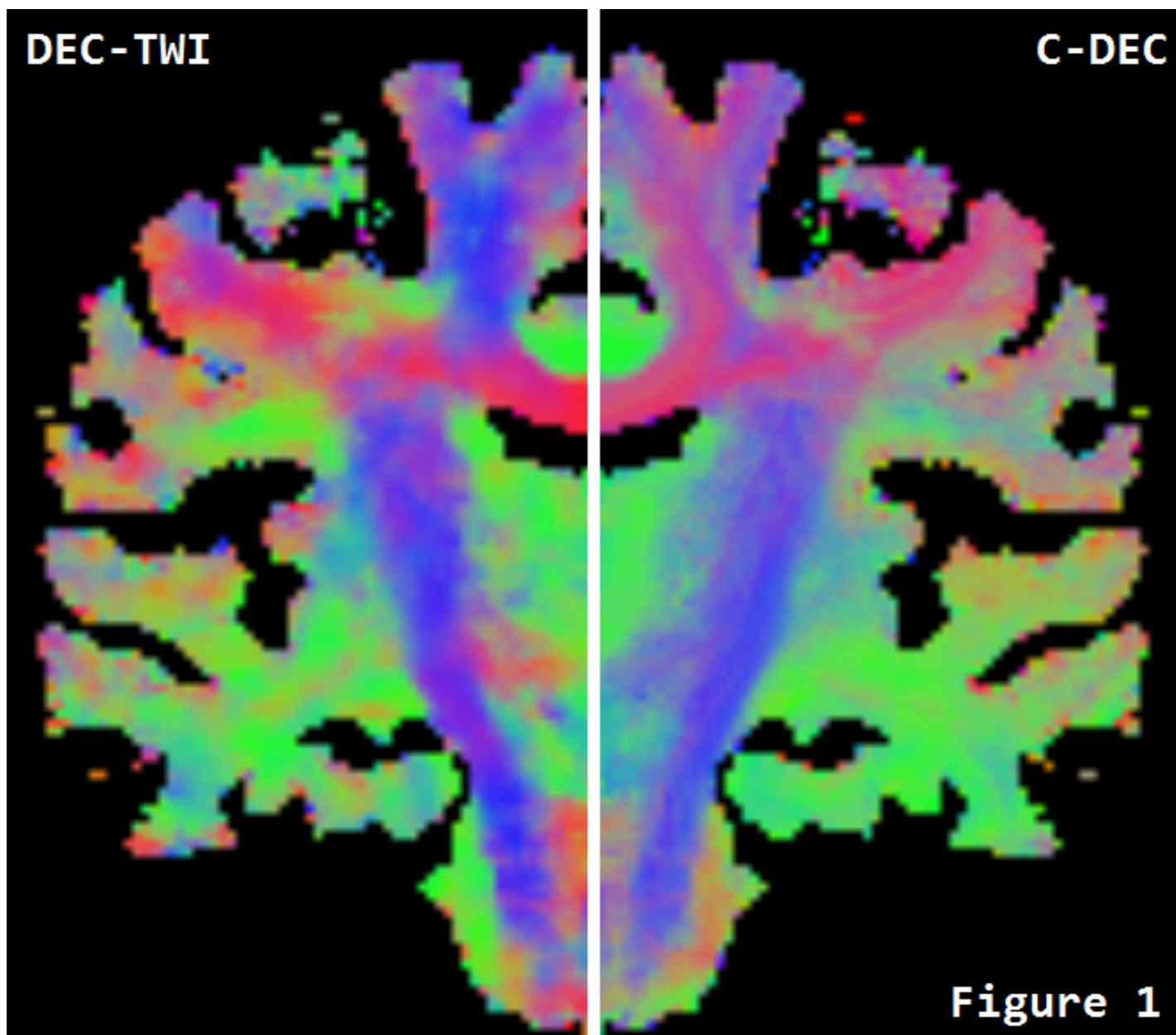
Methods:

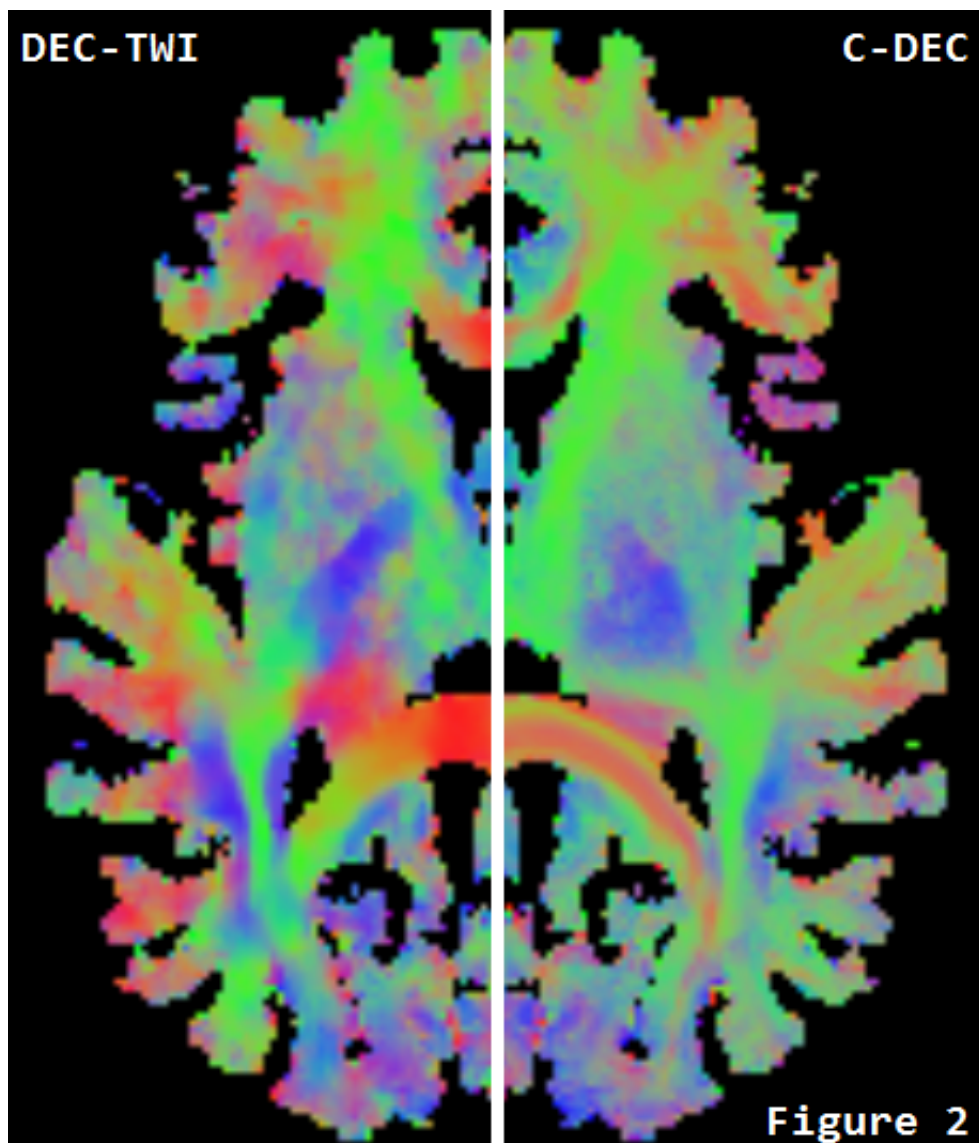
We propose the method Connectivity directionally-encoded color (C-DEC) map, which maps the average orientation of streamlines going through each voxel. We define the orientation of a streamline as the absolute value of the unit length vector connecting both extremities. For every streamline intersecting each voxel, the average orientation vector is taken (the normalized sum of the orientation of all vectors). The length of the segment of a streamline intersecting the boundaries a voxel depends on the position of the streamline and the voxel. In this study, we weighted the contribution of each streamline orientation to the average orientation by the length of the segment of the streamline in the voxel. In a similar fashion, we generated the DEC-TWI map, averaging the orientation of segments of streamlines intersecting the voxel. Thus, DEC-TWI is a map of the local structure orientation in the voxel and C-DEC is a map of the 'global' structure orientation going through the voxel, both estimated from streamline tractography. The color-coding of the average orientation is the standard red-green-blue convention (red: left-right, green: anterior-posterior, blue: inferior-superior) (Calamante et al., 2012, Pajevic et al., 1999).

DW images were acquired on a single volunteer along 64 uniformly distributed directions using a b-value of $b=1000$ s/mm² and a single $b=0$ s/mm² image using the single-shot echo-planar imaging sequence on a 1.5 Tesla SIEMENS Magnetom. An anatomical T1-weighted 1mm isotropic MPRAGE image was also acquired. Fiber Orientation Distribution Functions (fODFs) reconstruction were done using Mrtrix (Tournier et al., 2012) with spherical harmonics of order 8. Deterministic streamline tractography was done using the in-house algorithm described in (Girard and Descoteaux, 2012), seeding from the WM gray matter interface and using the particle filtering tractography algorithm (Girard and Descoteaux, 2012). All reconstructed streamlines have a length greater than 10mm and end in gray matter regions, ensuring that incomplete streamlines do not bias the orientation estimation.

Results:

Figures 1 and 2 show DEC-TWI maps on the left side and C-DEC mirror maps on the right side at a resolution of 1mm isotropic. Some WM bundle can be more easily identified and distinguished on the images on the right. For instance, in Figure 1, we can follow the corpus callosum (red) and cortical spinal tract (blue) while they merge near the cortex. Figure 2 shows the splenium of the corpus callosum (red) merging with the optic radiation (green).





Conclusions:

We provided a novel method to map streamlines in a color image, which can be generated from any set of streamlines. We think Connectivity directionally-encoded color maps can improve connectivity analysis by helping with streamlines visualization and WM bundles identification.

Neuroanatomy:

White Matter Anatomy, Fiber Pathways and Connectivity

Reference

Calamante, F., Tournier, J.-D., Smith, R. E., & Connelly, A. (2012). A generalised framework for super-resolution track-weighted imaging. *NeuroImage*, 59(3), 2494–503.

Fornito, A., Zalesky, A., & Breakspear, M. (2013). Graph analysis of the human connectome: Promise, progress, and pitfalls. *NeuroImage*, 80, 426–444.

Girard, G. and Descoteaux, M. (2012) Anatomical Tissue Probability Priors for Tractography. Paper presented at Computational diffusion MRI (CDMRI) workshop held at MICCAI. October 5th. Nice, France.

Hagmann, P., Kurant, M., Gigandet, X., Thiran, P., Wedeen, V. J., Meuli, R., Thiran, J.-P., Jan. (2007). Mapping human whole-brain structural networks with diffusion MRI. *PloS one* 2 (7).

Pannek, K., Mathias, J. L., Bigler, E. D., Brown, G., Taylor, J. D., Rose, S. E., Mar. (2011). The average pathlength map : a diffusion MRI tractography-derived index for studying brain pathology. *NeuroImage* 55 (1), 133–41.

Pajevic, S., & Pierpaoli, C. (1999). Color schemes to represent the orientation of anisotropic tissues from diffusion tensor data: application to white matter fiber tract mapping in the human brain. *Magnetic resonance in medicine : official journal of the Society of Magnetic Resonance in Medicine / Society of Magnetic Resonance in Medicine*, 43(6), 921.

Tournier, J.-D., Calamante, F., & Connelly, A. (2012). MRtrix: Diffusion tractography in crossing fiber regions. *International Journal of Imaging Systems and Technology*, 22(1).