

# Distortion Correction and Registration

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## 1. Who will benefit from this information?

The information in this presentation will be relevant to anyone doing quantitative analysis of diffusion imaging. Distortion correction methods improve accuracy and reproducibility of results. Co-registration is widely utilized in group studies such as voxel based morphometry.

## 2. How was a problem determined?

Distortion in echo planar imaging (EPI) has been extensively studied both in the context of diffusion imaging and in other uses of EPI such as BOLD fMRI.

Registration of diffusion images has evolved rapidly over the last decade with the development of techniques to preserve anatomical alignment of white matter fiber bundles, the use of tensor-based metrics to drive registration, and the development of mathematical frameworks to interpolate tensor data.

## 3. Examples of how this issue has been addressed

### *3.1. Part 1: Distortion correction.*

We will demonstrate examples of distortion and address their causes and best practices for their correction. Specific topics:

- EPI distortions: field inhomogeneity, susceptibility artifact, eddy currents.
- Physiologic noise: CSF pulsation, patient motion.
- Distortion minimization and correction techniques.

### *3.2. Part 2: Registration.*

We will highlight the additional challenges introduced by warping and resampling tensor data and the orientation density functions from high angular resolution models. Specific topics:

- Preserving anatomical alignment of white matter tracts after reorientation.
- Interpolation and resampling of tensor fields.
- Image similarity metrics for diffusion tensor data.
- Registration beyond the diffusion tensor

## **4. What will learners be able to do differently because of this information?**

After taking the course, learners should:

- Understand the causes, visual appearance and quantitative effects of different kinds of artifacts in diffusion imaging.
- Understand the importance of distortion correction in the diffusion imaging pipeline.
- Recognize and apply best practices for distortion correction.
- Be aware of techniques to minimize the appearance of distortion in the image acquisition.
- Understand the potential advantages and additional challenges involved in spatial normalization of tensor and HARDI data.
- Be aware of free software implementations that provide distortion correction and registration abilities.

## **Reading list**

Daniel C Alexander and James C Gee. Diffusion-Tensor Image Registration, chapter 20, pages 327–344. Springer, 2006. In: Visualization and processing of tensor fields, J Weikert and H Hagen, Editors.

Hao Huang, Can Ceritoglu, Xin Li, Anqi Qiu, Michael I. Miller, Peter C M. van Zijl, and Susumu Mori. Correction of B0 susceptibility induced distortion in diffusion-weighted images using large-deformation diffeomorphic metric mapping. *Magn Reson Imaging*, 26(9):1294–1302, Nov 2008.

Derek K Jones and Mara Cercignani. Twenty-five pitfalls in the analysis of diffusion MRI data. *NMR Biomed*, 23(7):803–820, Aug 2010.

David Raffelt, J-Donald Tournier, Jurgen Fripp, Stuart Crozier, Alan Connelly, and Olivier Salvado. Symmetric diffeomorphic registration of fibre orientation distributions. *Neuroimage*, 56(3):1171–1180, Jun 2011.