Adaptive Control Grid Interpolation of DTI Data

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Introduction

DTI is a useful tool for studying neuronal fiber structures of the human brain in vivo. However, the physical limitations on resolution and voxel size when using EPI-based techniques pose a challenge for detailed studies of white matter structure. Efforts have been made to increase in-plane resolution using parallel imaging [1] and to increase 2D/3D resolution via post-processing [2]. Recently, adaptive control grid interpolation (ACGI) has been demonstrated for enhanced 3D visualization of vascular geometry [3]. ACGI is a post-processing method that combines features of optical flow-based and block-based motion estimation algorithms developed for frame prediction in movies and camera video. This technique can accurately enhance spatial resolution of MR data sets with minimal computational complexity. In this study we applied ACGI to improve spatial resolution of DTI data.

Methods

Diffusion tensor images were acquired using a diffusion weighted single-shot spin echo EPI sequence. A dual spin echo technique was employed to minimize the geometric distortion induced by eddy currents. Diffusion weighted gradients were applied in 12 directions. A normal volunteer underwent MRI DTI examination that was carried out on a 3 T Siemens Trio system. The following parameters were used to obtain an 18 slice data set with 2 mm slice gap and a 36 slice data set with 0 mm slice gap: TR=5000ms, TE=90ms, FOV=23cm×23cm, slice thickness=2mm, b=0, 1000s/mm^2, and 4 averages. Images (128×128 matrix size) were acquired in the axial orientation.

ACGI is based on the generalized motion model to track the spatial displacement of the anatomical structure from one slice to another in order to establish the vectors along which to interpolate. While conventional interpolation techniques rely on weighted average of the slices, ACGI follows structure in a 3D fashion that allows better accuracy and avoids blurring. ACGI, implemented in Matlab, was applied to the multi-slice DTI images acquired with 100% skip to generate the skipped slices. Interpolations were performed on the raw diffusion images to obtain the volume data with a voxel size of 09×0.9×2 mm^3. Then, the diffusion tensor was calculated based on the interpolated data set using DtiStudio (Johns Hopkins Univ.). The resultant fractional anisotropy (FA) was compared with that obtained from the experimental data set without skip. We also compared ACGI with linear interpolation.

Results and Discussions

Fig. 1 shows representative FA maps in the sagittal plane obtained from a) the experimental data without gapping, b) ACGI of the data with 2mm gaps, and c) linear interpolation of the data with 2mm gaps. The results demonstrate that ACGI works reasonably well in generating the skipped slices and that the FA map generated from the interpolated data using ACGI is comparable to that from the experimental data set without gapping. ACGI recovered the corpus callosum (CC) better than linear interpolation (see arrows in Fig. 1c where linear interpolation failed). A comparison of ROI measurements of FA was performed in the genu and splenium of the CC; the results are shown in Table 1. FA values in CCg and CCs from ACGI are negligibly lower than those from the experimental data acquired without gapping, while linear interpolations resulting in significantly smaller FA values with relatively larger variations within the ROIs. Qualitative comparison between ACGI and linear interpolation showed that ACGI results in less blurring and better edge definition in the slice selection direction (not shown). Application of ACGI provides additional flexibility in image acquisition, permitting the acquisition of fewer slices with a gap to reduce SAR and avoid the cross talk between slices, while maintaining adequate coverage of the brain volume. ACGI could also be applied to data sets containing contiguous slices for ultra-high resolution DTI or to diffusion tensor field for an improved tracking of white matter fibers.

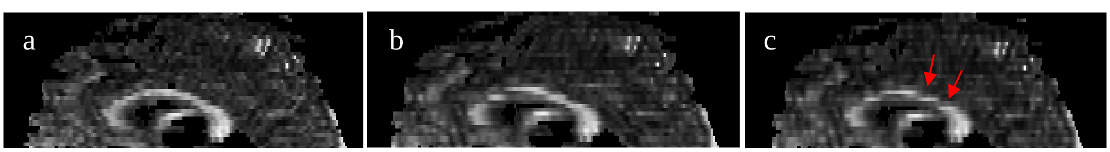

Figure 1. FA maps of sagittal plane in a volunteer obtained from (a) DTI experiment without gap, (b) ACGI, and (c) linear interpolation.

	DTI (Exp.)	ACGI	Linear
CCg	0.61 ± 0.04	0.60 ± 0.05	0.58 ± 0.07
CCs	0.72 ± 0.09	0.71 ± 0.11	0.69 ± 0.12

Table 1. ROI measurements of FA obtained from DTI experiment, ACGI and linear interpolations.

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References

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