High resolution diffusion tensor image using segmented FOV

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Introduction

Diffusion tensor imaging is highly sensitive to bulk motion, hence single-shot EPI is the most widely used readout module for diffusion imaging. However, the susceptibility resulting from regional magnetic field inhomogeneity distorts the EPI images due to long readout train. Shortening the acquisition window is the ultimate remedy. In this work, reduced FOV along the phase encoding direction was proposed to reduce the phase error aggregation. The zoom EPI technique was adopted in this work [1] to avoid the aliasing artifacts from signal outside the reduced FOV. Due to the small number of phase encoding, the distortions are greatly reduced even without SENSE acceleration. We further proposed a method inspired by the line-scan technique [2] to combine multiple images from single shot zoom EP-DTI to form a full FOV image.

Methods and Materials

Volunteer experiments were performed on a 3.0 T Philips Achieva system. A six-direction DTI sequence was adopted in this study. Slice thickness was 4 mm and the in-plane resolution was 1x1 mm^2 with the matrix size 224x56. Echo time was 64 ms and the TR was 4000ms. The b value for DTI was 700 s/mm^2. The excitation slice and the refocus location were applied obliquely as indicated in Fig 1. The FOV was shifted to acquire the image in the adjacent location after a TR duration. Each DTI has been averaged over 4 times to improve the image quality.

The sampled scheme to acquire a full FOV image was shown in Fig 2. After the whole regions of interest were sampled, the fringe boundaries were cut out to keep off the inhomogeneous excitation with each region sewed together to form a full FOV image for each diffusion weighted images. The DTI indices were subsequently derived. A full FOV EP-DTI with SENSE factor of 4 with the same resolution was also acquired for comparison.

Results

The single rFOV image using EPI acquisition without SENSE was shown in Fig.3, in which the phase encoding direction is in from R to L. A full FOV image combined from multiple partial VOI images were put in Fig 4(a). The full FOV image with SENSE is shown in Fig 4(b). The corresponding color FA map was shown in Fig.5. One particularly notices the residual unfolding artifacts in the Fig.4b (arrow) and the lowered SNR in Fig.5b.

Discussion

It was shown in Fig 4 that the distortions in b0 image were similar. However, the right frontal side in the SENSE (Fig 4b) image showed inevitable unfolding artifacts resulted from the mismatch between the sensitivity map in SENSE and the image due to distortion. From the color FA map (Fig 5), the image distortion and contrast were also similar. The color FA map in the left lower side in Fig 5(a) showed shaper boundaries. In Fig 5(b), the lower SNR in the center region than in the outer region is anticipated to be caused by the imperfect G factor in SENSE reconstruction. Therefore, our results suggest that the full-FOV image produced from the zoom technique could provide equal effectiveness as using SENSE in terms of reductions in geometric distortions. In addition, compared with SENSE at equal distortions, the proposed method is advantageous in its absence of unfolding artifacts and better SNR at similar imaging acquisition time.

Reference

1. Wheeler-Kingshott, C.A., et al., Magn Reson Med, 2006. **56**(2): p. 446-51.
2. Yongbi, M.N., et al., NMR Biomed, 1997. **10**(2): p. 79-86.

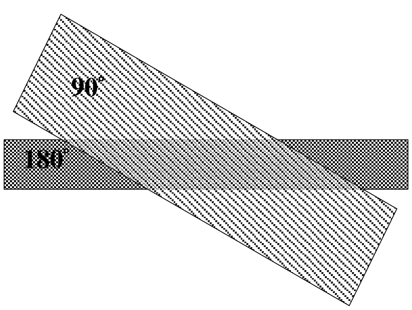


Fig 1. The schematic illustration of slice selection pulse.

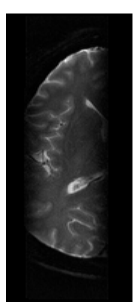


Fig 3. The single rFOV image without fold-over artifact was sampled by zoom EPI technique. The outer volume was suppressed due to no refocus by the echo pulse.

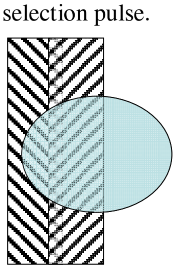
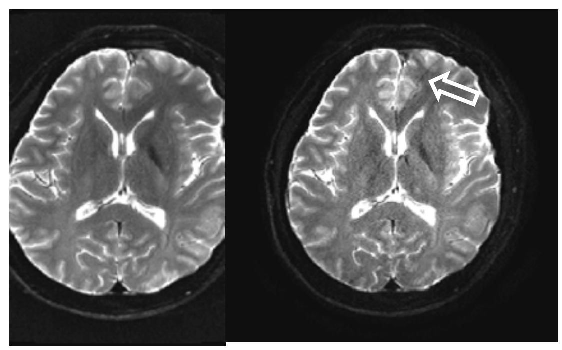
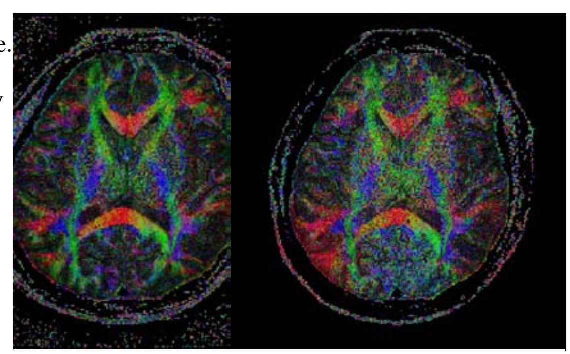


Fig 2. Sampling scheme to acquire full FOV. Circular region is denoted for the imaging object. Each rectangle shows the FOV for each scan with some overlap area to the other region.



(a) (b)

Fig4. (a) The combined b0 image from all sampled partial FOV images. (b) B0 image using SENSE with acceleration factor 4.



(a) (b)

Fig5. (a) The combined color FA image from all sampled partial FOV images. (b)The color FA with SENSE reconstruction