DISTORTION REDUCTION IN EPI BASED ON MINIMAL FIELD OF VIEW

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Objective: To reduce EPI spatial distortions and improve retrieval of information from areas mapping to the same location in space – signal "pile-up".

Introduction: The spatial distortions generated in the phase-encode direction in Echo Planar Imaging (EPI) can lead to misregistration of EPI images to the underlying anatomy [1]. Single shot EPI is the most common pulse sequence used for both functional MRI (fMRI) and diffusion weighted imaging, including diffusion tensor imaging (DTI). The minimal FOV method outlined herein aims to reduce distortions and thus improve spatial localization of fMRI activity and tracts computed from DTI. Avoiding artifactual spatial distortion (or image degradation resulting in loss of signal) is particularly important in neurosurgical applications in which the precise localization of brain areas is required.

Method:
This approach to EPI undistortion involves modifying both the acquisition and postprocessing phases of EPI. The encoding is altered to capitalize on the fact that the head is narrower in the left-right axis than along the inferior-superior or anterior-posterior axes. Despite these brain dimension differences, the field of view (FOV) used in axial brain EPI is routinely chosen to be square. However, if the phase encode direction is set to be left-right, this allows a decrease of phase FOV of at least 25%. Decreasing the FOV in the phase-encode direction increases the bandwidth per unit length by increasing the EPI echo spacing in *k*-space. The time between echoes does not change when the phase FOV is changed so the distortion is reduced proportionally to the increase in bandwidth. Contrary to conventional methods of reducing the phase FOV, here the original matrix size is purposely retained, resulting in higher effective resolution in the phase-encode direction. This spreads out the signal over more pixels, reducing irreversible signal "pile up" in areas of high inhomogeneity, thus in turn allowing more effective undistortion. EPI data were acquired on a 3T GE scanner version 12.0, with matrix size 128x128 and ramp sampling, TE=30ms ,TR=2s, phase encoding direction left-right, zoom gradient (4 G/cm). Distortions were corrected with the help of a double-echo gradient-echo fieldmap, after phase unwrapping [2].

Figure 1: Phantom results

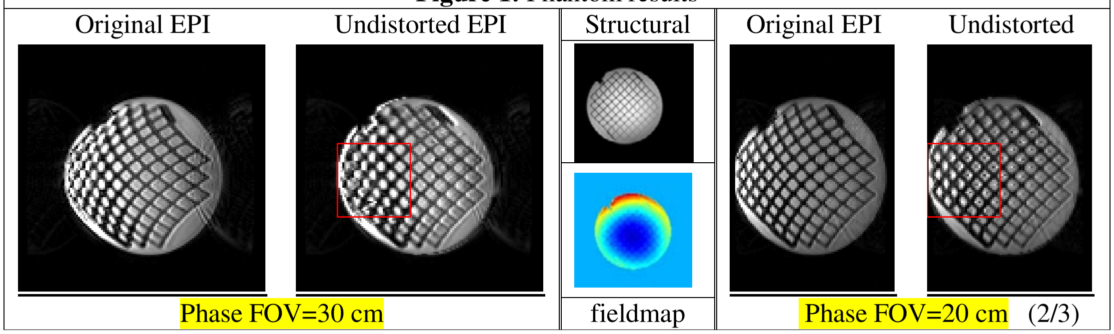
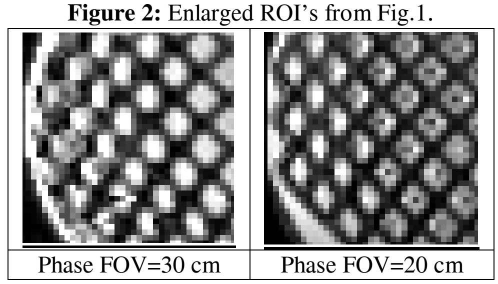


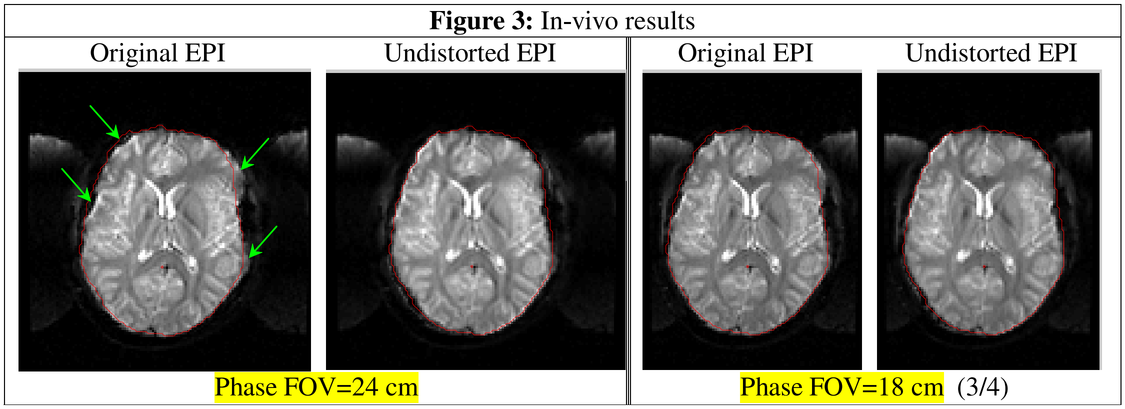
Figure 2: Enlarged ROI's from Fig.1.



Results:
Figure 1 shows the obviously better detail obtained in a phantom using 2/3 phase FOV – ROI's enlarged in Fig. 2. Figure 3 shows subtle improvements in brain EPI with this method, although the level of restored detail is hard to assess. Green arrows indicate distorted areas.

Summary:
when EPI distortions are a problem, it is recommended to use the minimal phase FOV possible while retaining the matrix size. High resolution DTI acquisitions should benefit most from this method. Possible next steps include the combination of minimal FOV with parallel imaging.

Figure 3: In-vivo results



Acknowledgement: NIH U41RR019703

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