Single-Scan Spatially Encoded MRI - Principles & Applications

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Introduction

The ability to acquire 2D NMR images in a single-scan is essential to both clinical and research applications. The most widespread technique for producing such images is Echo Planar Imaging (EPI). Notwithstanding its ongoing enhancements EPI is still limited, particularly when operating under non-ideal conditions such as inhomogeneous magnetic fields, inherent susceptibility artifacts or multiple chemical shifts; all these factors may act as major sources of image distortions. Recent studies have introduced an alternative scheme for achieving single-shot imaging, based on imparting a spatial rather than the standard temporal encoding of the spin interactions [1,2]. This Spatial-Encoding Imaging (SEI) scheme employs quadratic phase manipulations [3], and is characterized by the sequential addressing of different locations along a specific axis at different times – both during the excitation and acquisition stages. Integration of the conventional time-encoding and of this new spatial-encoding scheme respectively along the RO and PE axes of an ultrafast 2D MRI experiment produces a hybrid 2D sequence whose performance can be superior to that of conventional EPI when operating under non-ideal environments.

Methods

Experimental data were acquired on a Varian VNMRJ 7T vertical-imaging unit. Phantom images comparing 2D SEI and EPI were performed under controlled inhomogeneities of 100-200 Hz with FOVs of 25x25 mm^2 and slice thickness of 4 mm. Corresponding murine brain images using an axial orientation with similar FOVs and slice thickness of 1.8 mm were also collected.

Results

The potential of SEI can be appreciated from the attached figures displaying images of a cross-shaped phantom and of an axial slice of murine brain. SEI images were acquired using a novel variant of the hybrid Spatial/Temporal encoded (SE/TE) sequence, capable of producing T_2^* compensated images by self-refocusing the effects of field inhomogeneities during the acquisition process itself. Figure 1 illustrates good reinstatement of the image achieved by this SE/TE hybrid variant (middle), as compared to the Spin-Echo EPI sequence (left). In Figure 2 poor shimming conditions provided an inhomogeneity range of 600-800 Hz which prevented the acquisition of high-definition EPI images. Still, apart from SNR losses, the T_2^*-compensated SEI approach succeeds to provide basic structural features even in these settings.

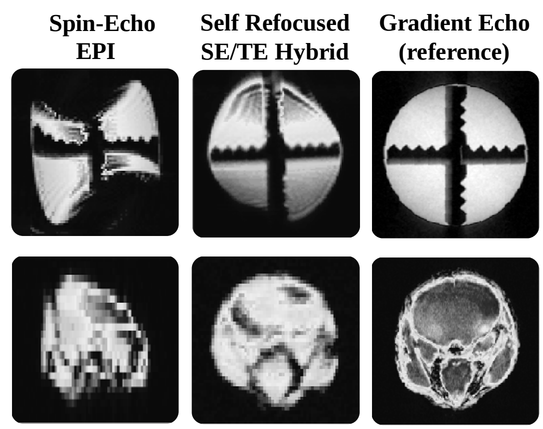

Fig. 1: 2D Images of a cross shaped phantom.

Fig. 2: 2D Images of Murine brain.

Discussion

Hybrid SEI provides a potential alternative for single-scan 2D imaging. The spatial locality of this imaging approach allows one to design different types of pulse sequences including self-refocusing variants like the one employed in Figures 1 and 2, which are capable of single-scan imaging even under conditions that challenge EPI. Additional sequence protocol will be presented, having the ability to significantly shorten the reconstruction time of 2D images by parallelizing its acquisition process. This is achieved by simultaneously addressing two locations within the sample during both the encoding and decoding stages. When used under non-ideal conditions, this technique could prove valuable for delivering high-definition images even for regions which might otherwise be inaccessible using existing ultrafast techniques.

References

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