SENSE Motion Correction

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Introduction

A self-navigated motion-correction technique using SENSE and a multiple-shot FSE sequence is presented. Importantly, two images are reconstructed from the same acquired data: the first is a direct reconstruction from the full k-space data set; the second is formed by registering and combining individual images reconstructed using SENSE on data collected in each shot.

Methods

Data were collected using an 8-channel head coil and a modified FSE sequence with an echo train length of 32. The number of lines acquired in the phase-encode direction was chosen to be 128; therefore, 4 shots were required to fill k-space. An image was reconstructed directly from the full k-space data set. A second reconstruction was formed by generating an image from each individual shot using SENSE and then registering and combining these (Fig. 1). The acquisition time of a single shot is very short; thus, minimal motion occurs within this interval.

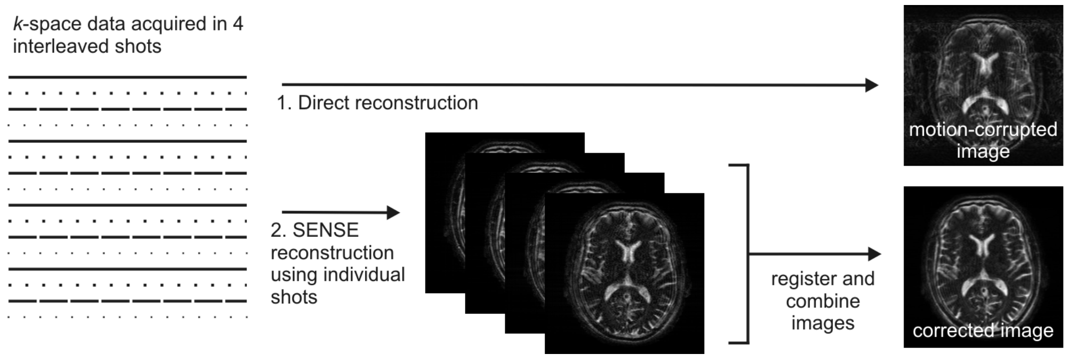

Figure 1: Reconstruction of two images from the single k-space data set. The direct reconstruction produces an image with better SNR than that reconstructed using SENSE and image registration. However, motion correction is possible in the latter case. Both images are available to the end user.

The SENSE reconstruction method proceeds as follows. The support constraint of the object is used to improve the SNR in the reconstructed image as described in [1]. Coil sensitivity maps for each coil, and the support region of the object, were estimated using a low-resolution 32 × 32 image. This data set is small enough to be acquired in a single shot, reducing problems caused by motion. A polynomial function was fitted to each sensitivity map allowing extrapolation of the map slightly beyond the boundaries of the object [1]. This was necessary as, with motion, part of the patient may move outside the region over which the coil sensitivity map is directly estimated. Image registration of the four images was performed using code written by the authors based on that used in [2] for rigid-body rotation and translation estimation.

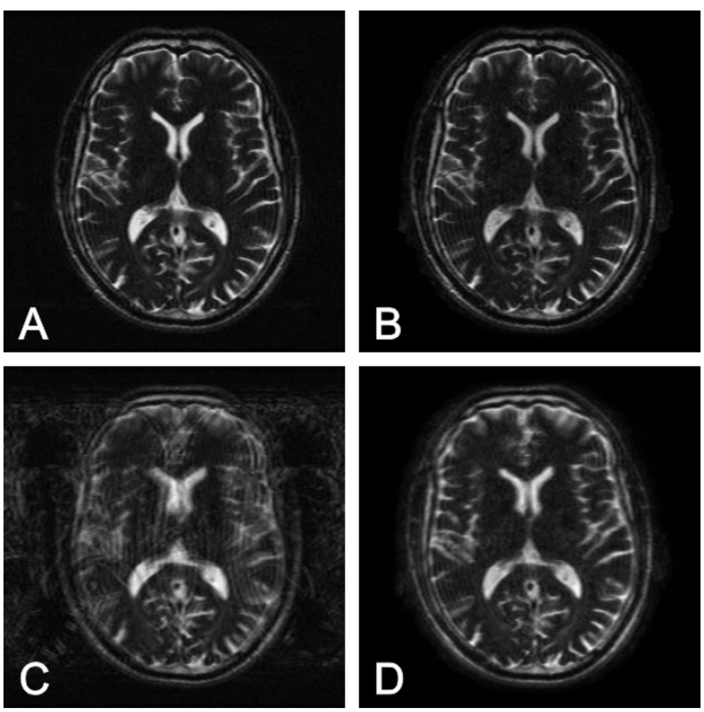

Figure 2: A comparison of images using the direct reconstruction (A and C) and the proposed SENSE reconstruction technique (B and D). The subject was stationary during collection of the data forming A and B and moved during collection of the data forming C and D.

Results

Imaging was performed on a normal volunteer, instructed to stay still during the first scan, and to move continuously in the second. Reconstructed images from one slice are shown in Fig. 2. Maximum motion detected by the registration algorithm for the second scan was a rotation of 3.9º and a translation of 5.5 pixels (*x*-direction) and 1.0 pixels (*y*-direction).

Discussion

Some motion blur remains in Fig. 2D. We suggest that this is caused by slight motion within each shot and through-plane motion between shots.

Other successful motion-correction techniques such as PROPELLER [3] have some disadvantages over standard techniques, such as increased acquisition time. Clinicians must decide in advance whether motion is likely and choose the imaging sequence based on this. The approach proposed here avoids this problem as a standard reconstruction and a motion-corrected reconstruction are obtained from the same acquired data. In the absence of motion, the direct reconstruction is preferable due to improved SNR over the SENSE reconstruction. Only an 8-channel head coil was available for this research. The use of a 16-channel or 32-channel could enable the collection of 256 phase-encode lines, rather than only 128. This would improve the clinical utility of the method.

References:

[1] Pruessmann et al., Magn. Reson. Med. 45:952-962 (1999).
[2] Maclaren et al., Proc. ISMRM., p. 3427 (2007).
[3] Pipe, Magn. Reson. Med., 42:963-969 (1999).