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MOTION ARTIFACT CORRECTION USING STANDARD PULSE SEQUENCES

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INTRODUCTION

Translational motion during MRI acquisitions, causes artifacts in the reconstructed image. When this motion is inside the imaging plane and slow enough to be considered a view-to-view effect, it has been shown (1) that the result is a phase error in the acquired data given by

$$\phi(k_x,k_y) = 2\pi (k_x p(k_y) + k_y q(k_y)) \quad [1]$$

where k_x ,k_y are the spatial frequency coordinates with k_y being the phase encode and $p(k_x)$, $q(k_y)$ the displacement in the read out and the phase encode direction respectively.

If the displacements were known, the data could obviously be easily corrected. In this work we describe how this can be done using only data acquired via MRI techniques, without any external devices or navigator echoes.

ANALYSIS

Motion information extraction

The projections of an object in a certain direction at different points in time, provide information about its movement in that direction. Projections in two perpendicular directions contain sufficient information for determining the translational motion of the object. Moreover, in a Fourier method, where each line of data is acquired in the presence of a read-out gradient, the FT of this line is a projection in the direction of that gradient. Of course it is not a projection of the original image but of the phase encoded image. Such a projection, though not exact, retains an important property of the corresponding exact projection: both of them begin and end at the same positions (2).

Thus we can determine the position of the object on the read out axis, by taking the Fourier transform of each FID and calculating the first non-zero point of each transform. In the case of an object that is not moving in that direction, all these points will be at the same column. If the object is moving slowly enough for its motion to be considered a view-to-view effect, this set of points can determine one component of the object's motion.

To obtain a second projection, navigator echoes (NAVE) may be used (3). However, the phase encode gradient may replace the NAVE. Thus the standard pulse sequence does not have to be modified and only an additional acquisition is needed, which is obtained during the phase encode period. This suggests that the overall experiment time does not increase. Alternatively, the phase encode gradient may be modified in such a way so that during an initial stage it will act as a projection gradient in the phase encode direction and afterwards it will be brought to its standard value.

Motion artifact reduction.

Motion information acquired using the method described above, is used for artifact reduction in the following manner. The Fourier transform (FT) of each projection is calculated. The first non-zero points of the transforms are determined. These points show the displacement of the object in the phase encode direction which may be used in eq.[1] to correct the phase error caused by this component of the motion.

The half-corrected data are then used for the reconstruction as follows. After calculating the FT of each line, the first non-zero points of the transforms are determined. All the transforms are then shifted to begin at the same column. The column FT is then calculated to produce the reconstructed image.

In the case of one-dimensional motion in the read out direction, the imaging data are enough for an artifact free reconstruction.

RESULTS

The method was successfully tested using computer simulation. Spin-wrap data sets corrupted by translational motion, were initially simulated. Subsequent reconstruction using the method described above, succeeded in calculating the component of the motion in the read-out direction using only the imaging data and in completely removing any artifacts due to this motion component. In the two-dimensional case additional projections were used to correct the artifacts caused by the second component of the motion. An example reconstruction is shown in Fig.1.

CONCLUSION

Standard spin-wrap pulse sequences provide sufficient information for determining any translational motion of the imaged object. Artifacts can be removed with an extra set of acquired data and with a limited amount of post-processing time cost.

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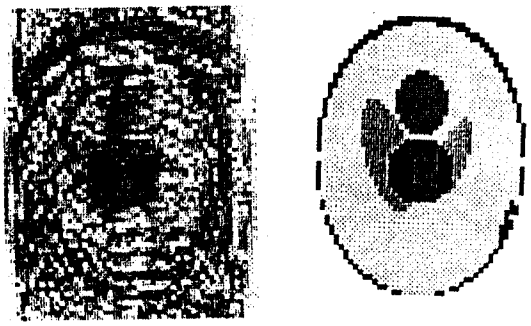

(a) (b)

(a) Image corrupted by translational motion.
(b) Corrected image.

Fig.1.