# Joint Estimation of Object Motion and SENSE Reconstruction

L. Ying[1], D. Xu[2], Z-P. Liang[2]

[1]Electrical Engineering, University of Wisconsin - Milwaukee, Milwaukee, WI, United States, [2]Electrical and Computer Engineering, University of Illinois at Uraban - Champaign, Urbana, IL, United States

## INTRODUCTION

Most parallel imaging methods, such as SMASH [1] and SENSE [2], require the sensitivity weighting function of each receiver channel for image reconstruction. The desired sensitivity functions are often derived from a set of reference images obtained in a calibration scan. A practical problem with this technique is that any object motion from the calibration scan to the accelerated scan can create significant image artifacts, which is a major concern in dynamic imaging applications. Although the problem can be alleviated through the use of self-calibration techniques [3-4], the sensitivity functions thus obtained are of low resolution. When high-resolution sensitivity functions are desired, it is necessary to correct the misalignment between the reference and the new sensitivity-encoded imaging data. Although there are many algorithms available for image registration [5], they are applicable only to the situations in which the images to be registered are already available. This paper addresses the motion correction problem by jointly estimating the motion parameters and the image function using a mutual information-based algorithm.

## METHOD

Similarly to the widely used technique for sensitivity estimation, we perform both a reference scan with full resolution and accelerated scans with reduced encodings. We further assume that the mismatch between the reference and accelerated scans can be characterized by a rigid-body transformation $\boldsymbol{T}_{\boldsymbol{\theta}}(\vec{x})$, where $\boldsymbol{\theta}$ contains the motion parameters. We jointly estimate $\boldsymbol{\theta}$ and the desired image function based on an information-theoretical criterion [6]. Specifically, the optimal motion parameters are given by

$$\boldsymbol{\theta}^* = \arg\max_{\boldsymbol{\theta}} \boldsymbol{I}\{\rho(\vec{x}), \rho_{\boldsymbol{r}}(\boldsymbol{T}_{\boldsymbol{\theta}}(\vec{x}))\}, \tag{1}$$

where $\boldsymbol{I}\{\cdot,\cdot\}$ denotes the mutual information between its two arguments, $\rho_{\boldsymbol{r}}(\boldsymbol{T}_{\boldsymbol{\theta}}(\vec{x}))$ is the reference image from a body coil after the coordinate transformation, and $\rho(\vec{x})$ is the desired image function governed by the SENSE reconstruction equation:

$$\mathbf{S}\vec{\rho} = \vec{d}\ . \tag{2}$$

In Eq. (2), $\vec{d}$ is the measured k-space data or the aliased image vector, and $\mathbf{S}$ is formed from the sensitivity functions estimated by the transformed reference images

$$s_\lambda(\vec{x}) = \frac{\rho_{\boldsymbol{r},\lambda}(\boldsymbol{T}_{\boldsymbol{\theta}}(\vec{x}))}{\rho_{\boldsymbol{r}}(\boldsymbol{T}_{\boldsymbol{\theta}}(\vec{x}))}, \tag{3}$$

where $\rho_{\boldsymbol{r},\lambda}(\boldsymbol{T}_{\boldsymbol{\theta}}(\vec{x}))$ represents the sensitivity-weighted reference image from the $\lambda$th channel. The information-theoretic criterion in Eq. (1) is particularly advantageous for this problem because it is independent of image contrast. By optimizing the transformation, the proposed algorithm effectively removes any motion artifacts in the SENSE reconstruction.

## RESULTS

We have tested our method on a number of real data sets with encouraging results. An example is shown in Fig. 1, where a set of real experimental data was acquired with 3 receiver coils and a reduction factor of 2. The object motion was introduced through computer simulation. When the mismatched reference images were used for obtaining the sensitivity functions without motion correction, the SENSE reconstruction contained significant image artifacts, as shown in Fig. 1 (a). The proposed method accurately determined the motion parameters and the SENSE reconstruction, as shown in Fig.1 (b).

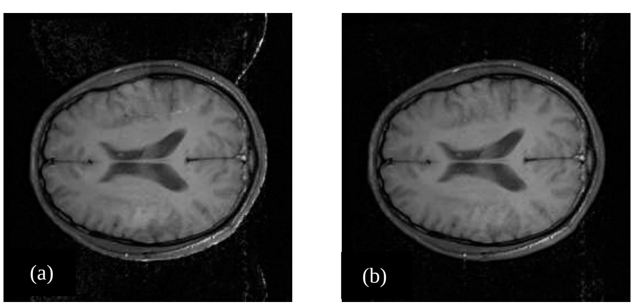


Figure 1: SENSE reconstruction (a) before and (b) after motion correction by the proposed method

## CONCLUSION

An effective method has been proposed for motion calibration in parallel MRI. The method jointly estimates the motion parameters and image function based on an information-theoretical criterion. Experimental results demonstrate that the proposed algorithm is rather effective in removing motion artifacts in conventional SENSE reconstructions.

## REFERENCES

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