# Detecting fMRI Activation in K-Space for High Acceleration Factors

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Introduction

Parallel imaging techniques can be used to increase either spatial or temporal resolution in fMRI. In practice, however, even minor imperfections in the undersampled reconstruction can mask those small variations that are pivotal to fMRI. Thus, many researchers are wary of acquiring undersampled data and simply accept the maximum resolution attainable without acceleration. What we demonstrate here is that the sparse nature of relevant fMRI activation data, rather than being an obstacle, can be an advantage for maintaining fidelity in accelerated imaging.
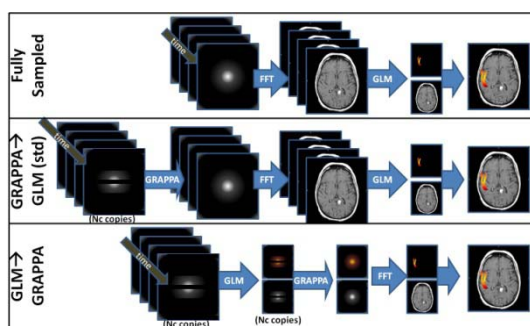

As has been demonstrated for undersampled MR angiography, simply switching the order of the subtraction step and the unfolding steps of the reconstruction allows higher accelerations to be achieved. This is because the subtraction results in sparser images, and the GRAPPA kernel is thus better tailored to the relevant pixels. We report a similar improvement in fMRI reconstructions simply by switching the order of the analogous steps in fMRI processing. Rather than reconstructing the individual time point images and analyzing those images for activation, we perform the GLM decomposition on the undersampled k-space. This results in k space data of sparse activation images, and the GRAPPA kernel is better tailored to the relevant pixels in the image.

Methods

Data were acquired in compliance with Yale IRB standards from a subject performing a finger tapping task. The motion corrected data consisted of four runs of 136 images per run. For each time point image, multichannel acquisition was simulated by multiplying the fully sampled image with coil profiles from an 8 channel coil; these were then transformed back into the k-space domain and subsampled to the appropriate acceleration scheme.

Results and Discussion

The first row of the figure shows the coefficients resulting from GLM analysis of fully sampled images. Image (a) is a map of coefficients

for the activated component of each pixel, i.e. a typical activation map. Image (b) is the static component which, as expected, is essentially a structural image.
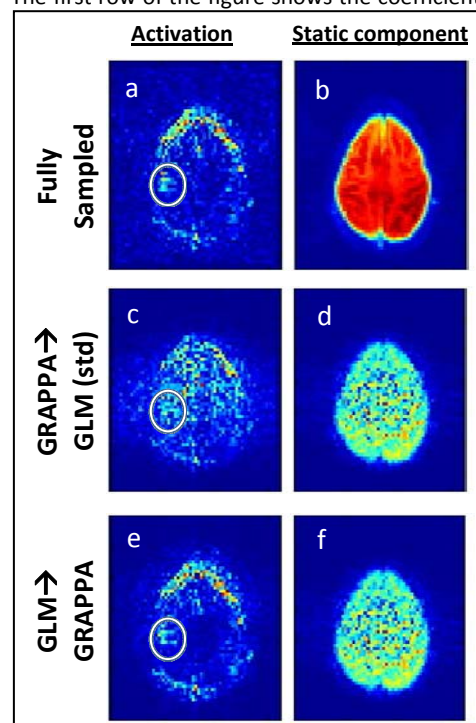
For the standard reconstruction of undersampled data, GRAPPA was applied to each undersampled k-space dataset of the time series. This resulted in a full time series of unfolded images. Finally, these composite images (root sum of squares of individual coil images) were analyzed for their static and time varying components using the same GLM model, thus creating the coefficient maps shown in Figures (c) and (d).

In the proposed approach, GLM analysis is applied directly to the time course of undersampled (single coil) k-space data to separate the static and time varying components. The resulting coefficients represent k-space data for folded images of the activated and static components. We then applied GRAPPA reconstruction to this data to yield the maps shown in Figures (e) and (f). While the map of the static component is degraded by the accelerated reconstruction, the activation map (e) is nearly identical to that seen for the fully sampled case. We present more rigorous justification of the validity of applying GLM time course decomposition to subsampled k-space data, and also explore k-space based motion correction that would be compatible with this approach.

References: Huang et al, MRM 56:642-649 (2008); Moeller et al, MRM, 63:1144–1153 (2009); Storey et al, Proc. ISMRM 18 (2010); Koktzoglou et al, MRM, in press (2010).