Sensitivity encoded imaging from multiple mode birdcage volumne coil

Fa-Hsuan Lin[1,2], Kenneth K Kwong[2], John W. Belliveau[2], Lawrence L. Wald[2]
[1]Havard-MIT Division of Health Sciences and Technology, [2]Massachusetts General Hospital Department of Radiology, MGH-NMR Center, Building 149, 13th St., Charlestown, MA USA;

Abstract In this paper we demonstrate the feasibility of using the SENSE[1] reconstruction method in conjunction with a volume birdcage head coil by simultaneously imaging with the uniform and gradient mode of the RF coil. When these two modes are tuned to the Larmor frequency, acquisition from the two spatially different modes allows the folded (reduced phase FOV) images to be reconstructed. Because the number of kspace lines is reduced by a factor of 2, this technique offers the potential to reduce susceptibility induced distortions in echo-planar imaging sequences used in fMRI while maintaining uniform, whole brain coverage.

Introduction Common applications of the birdcage coil are restricted to quadrature detection using the lowest order mode of the coil, a uniform B1 profile. The next highest frequency mode, the gradient mode, has been previously used for imaging[2] and for reducing encoding time using a kspace series expansion method[3]. Here we demonstrate the feasibility of SENSE reconstrution using simultaneous acquisition from the uniform and gradient mode of the birdcage.

Methods An eight rung low-pass, 26.3cm dia. birdcage coil was constructed for this study. The homogeneous (lowest order) mode was used for RF excitation using a four port (0°, 90°, 180°, 270°) drive. This was achieved with a conventional 90° hybrid driving two rungs 90° apart in conjunction with two $\lambda/2$ cables connecting these rungs to the opposite rungs. The 4 port drive is needed to ensure that only the uniform mode is driven during transmit.[2] The next highest frequency birdcage mode (the gradient mode) has no B_1 amplitude at the center of the coil as is usually not resonance with the MR signal. In this work, we tuned the gradient mode to the Larmor frequency using a resonant structure around the coil whose symmetry allows it to couple only to the gradient mode.[2] This structure has a zig-zag anti-Helmhotz configuration which also produces a B1 field gradient. Although not resonant at the Larmor frequency, it can be used to pull the gradient mode of the birdcage to a lower frequency while leaving the uniform mode unaffected.

In the *in vivo* sensitivity method [4], a coil map is not obtained, instead a low resolution but full FOV image is acquired (64x64 matrix and a 200mm x 200mm FOV). The half-FOV aliased image was acquired with a matrix of 64x128 and a 100mm x 200mm FOV. The spatial difference in the sensitivity profiles of two modes enabled the unfolding of aliased image. To increase the stability of the reconstruction, we use a Tikhonov regularization [5] to minimize the following cost function with respect to $\vec{\rho}$

$$\left\|A\vec{\rho}-\vec{O}\right\|_2^2+\lambda\left\|\vec{\rho}-\vec{\rho}^{\,*}\right\|_2^2$$

Here, $\vec{\rho}$ is the spin density ratio between the reference full-FOV acquisition and aliased acquisition. **A** is the aliasing matrix for both channels incorporating sub-sampling effect of k-space and full FOV reference images [4]. $\vec{\rho}^{\,*}$ is a prior estimate of $\vec{\rho}$. To the extent that the folded image data is static, $\vec{\rho}^{\,*}$ is unity. $\vec{O}$ is the collapsed observation from both channels. The regularization constant λ was estimated from Generalized Cross-Validation (GCV) [6]. After estimation of $\vec{\rho}$, the unfolded images of each channel are formed from a pixel-wise multiplication of $\vec{\rho}$ and the reference images.

Images were acquired from Siemens symphony 1.5T system using a phantom with brain-like structure using a spin-echo sequence (TR/TE/flip = 100ms/15ms/90°, 5mm slice).

Results Full FOV but reduced resolution images from the uniform and gradient modes are shown in Figure 1. Figure 2 shows the folded images from the 2 channels. The unfolded image is shown in Figure 3.

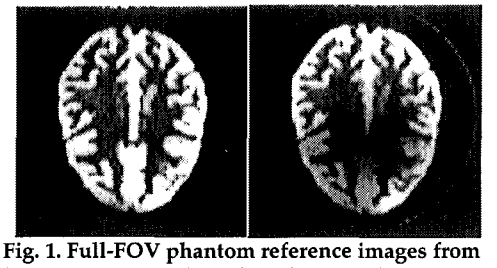

Fig. 1. Full-FOV phantom reference images from homogeneous mode and gradient mode

Fig. 2. Half-FOV aliased images from homogeneous mode and gradient mode

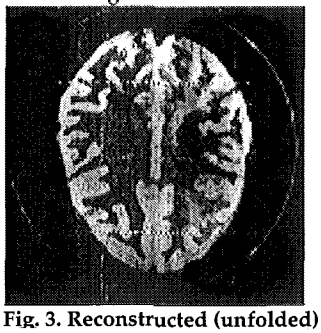

Fig. 3. Reconstructed (unfolded) image

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