Distance Weighted B1 Uniformity Correction for Multiple Channel Image Reconstruction

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Introduction

Image reconstruction using multiple-channel receive coils for data acquisition is desirable since it improves overall image quality due to increased signal-to-noise. Conventional multiple-channel image reconstruction techniques use a sum-of-squares algorithm to combine images from multiple receive coils(1). One drawback of this technique is image pixel hyper-intensity near coil elements and variations in image uniformity. Several post-processing techniques(2,3,4) exist to address this issue and we present a novel approach to this problem by using the images from each channel to automatically generate coil sensitivity maps that can be applied during image reconstruction to compensate for B1 non-uniformity.

Theory

Image reconstruction for each individual receive coil element shows high pixel intensity in regions near each respective receive coil element. When such images are combined using conventional techniques, these hyper-intense regions contribute to image pixel non-uniformity in the combined image. We examine a novel technique to generate coil sensitivity correction maps from the individual coil images, then apply these maps to the images from each coil prior to combination.

To generate the coil sensitivity maps, the image coordinates (x,y) of the maximum pixel intensity for each coil image are found. Then a coil sensitivity map for each coil is derived in the following manner. For each pixel location of each coil the Euclidean distance in image space, $d_i(x,y)$ is found to the maximum pixels for all coil images. The weight for each pixel is determined as the ratio of the distance from the local coil maximum divided by the summation of the distances to the maximum locations for all coils. These coil sensitivity maps are shown with their corresponding magnitude images in Fig. 1. Once generated, the coil sensitivity maps are applied multiplicatively to each individual coil image prior to combination.

Methods

Data were collected using a 1.5 T General Electric (GE) Optima MR450w scanner (GE Healthcare, Waukesha, WI, USA) equipped with a high bandwidth 2.5 MHz data acquisition subsystem and a gradient coil capable of 50 mT/m at a maximum slew rate of 200T/m/s. Conventional T2-weighted fast spin echo (FSE) scans were performed using an 8-channel head coil (Invivo, Waukesha, WI, USA). Data were collected from a number of human subjects under approved institutional review board agreements.

The following 2D FSE/XL scan was performed: 2D, Axial, flow comp, tailored RF, TR=5006msec, TE=101msec, field of view = 24 cm, flip angle =90, slice thick=5mm, skip=1mm, ETL=24, 512x512, 2 NEX. Raw data were saved and reconstructed off-line using MATLAB.

Results

Using identical data sets, a combined image generated with the proposed technique is compared to those generated using the sum-of-squares(1) with no intensity correction, SCIC(2) and PURE. The sum-of-squares image shown at the top left of Fig. 2 shows hyper-intensity near coil elements with darker regions near the center of the brain. The corresponding image with SCIC(2) applied provides brightening of regions near the center of the brain, but some hyper-intensity near the anterior portion of the brain is still visible. (See top right of Fig. 2)

PURE correction is based on a reference scan(3,4) and the resulting PURE corrected image is shown at the bottom left of Fig. 2. Similar to SCIC, center regions of the brain are brightened and some hyper-intensity near the anterior region of the brain is visible. The image shown on the bottom right of Fig. 2 was generated using the new algorithm, with the coil sensitivity maps shown in Fig. 1 applied prior to image combination.

Discussion and Conclusions

In comparing the results of SCIC and PURE correction to the new algorithm, we observe that the new algorithm balances pixel intensities throughout the brain in a similar fashion as SCIC and PURE. The brightness visible near the anterior portion of the brain is reduced with the new algorithm. The new technique eliminates the need for a reference scan as required by PURE and reduces misregistration artifacts that may occur due to patient motion in between the reference scan and the multiple-channel acquisition. The proposed technique is simple and robust and provides effective B1 uniformity correction.

References
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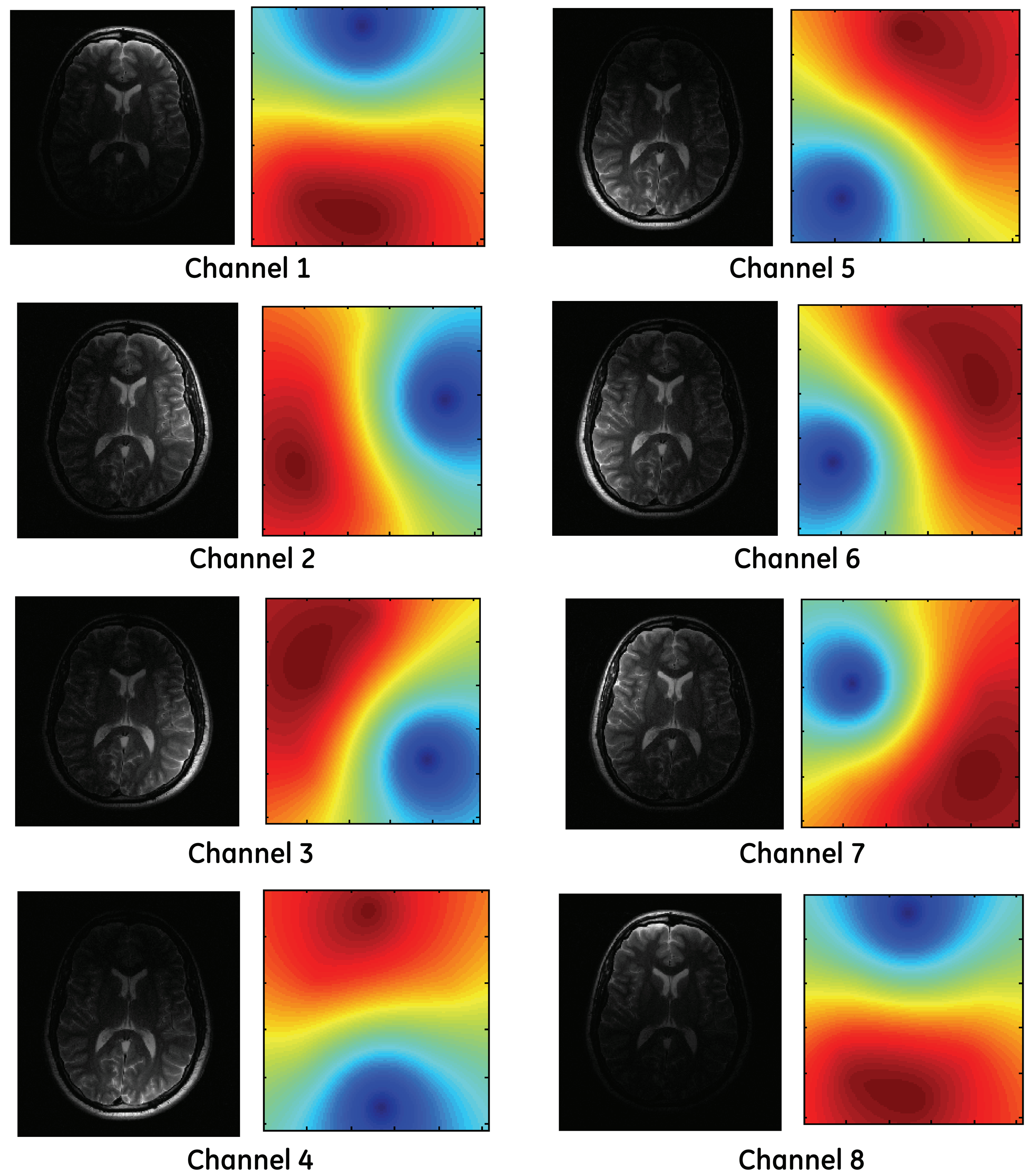

Fig. 1: Magnitude images from each receive channel with corresponding coil sensitivity maps derived from Euclidean distance of the maximum pixel intensity from within the individual coil image.

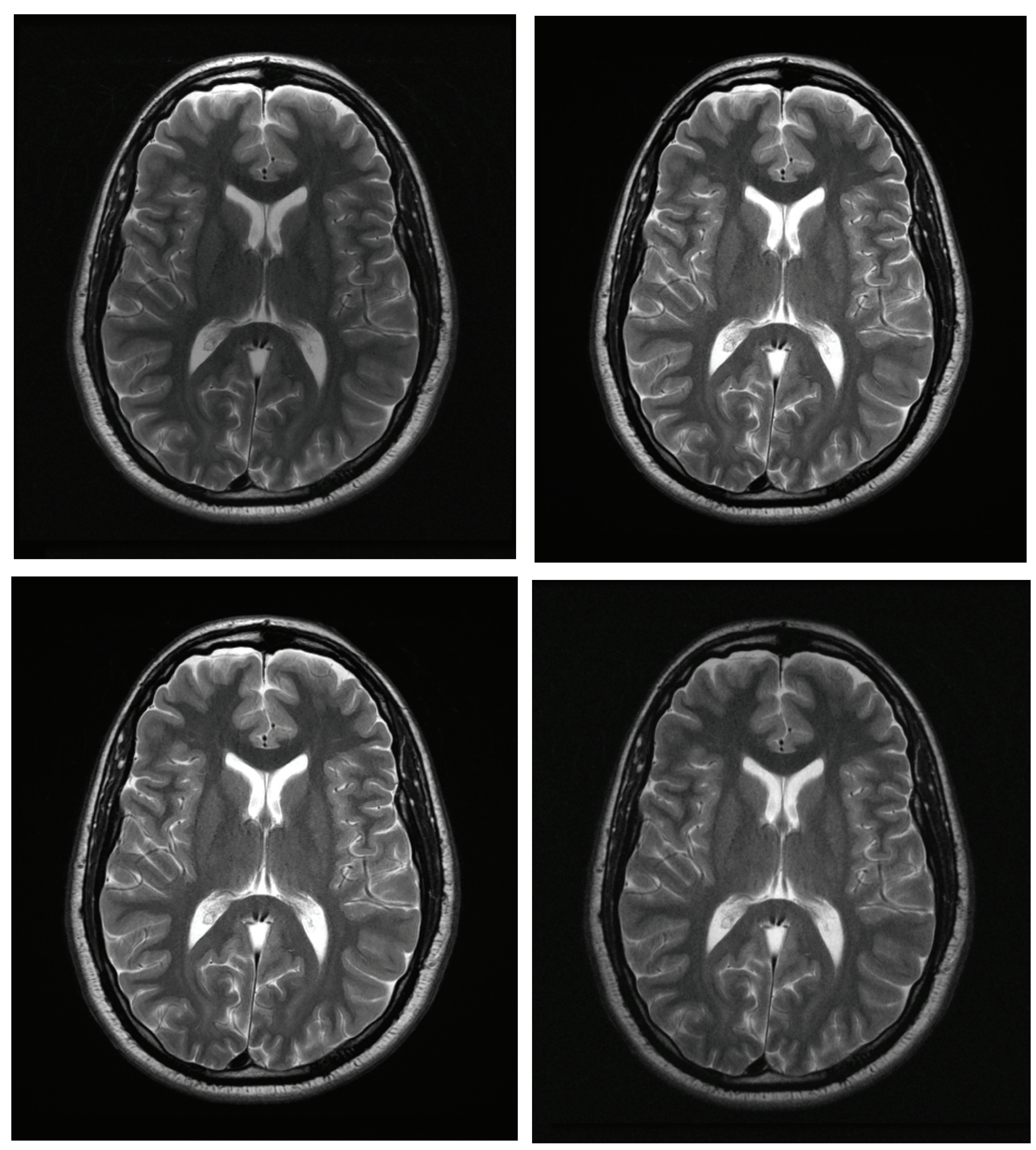

Fig. 2: Combined magnitude images. Upper left – No correction; Upper right – SCIC; Lower left – PURE; lower right – Using Coil Sensitivity maps derived from Fig 1.