

## Intensity Correction using Eigen modes of channels

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**Introduction:** It is known that the intensity homogeneity in SENSE [1] reconstructed images is dependent on the uniformity of the acquired calibration data. The calibration data may be obtained from a pre-scanned image or from a low-resolution image created from the auto-calibration signal (ACS) lines in the center of k-space. In this work, we propose a new technique for intensity correction of SENSE reconstructed images using Eigencoil® [2], [3] combination of channels to partially solve the uniformity problem that arises from calibration data, that is not acquired using the body coil. Here, we use a software version of the Eigen mode combination to generate a low-resolution homogeneous image from ACS lines and use it to correct for the intensity inhomogeneity problem.

**Methods:** The sensitivity maps for SENSE images are typically computed from a low-resolution calibration image, which, as mentioned previously is generated either from a pre-scan or from ACS lines. The sensitivity maps are obtained using normalization by straight square root of sum of squares (SoS) of the acquired calibration data as shown in equation (1). In our case, the sensitivity maps were obtained by normalizing the calibration data with the primary mode of the Eigencoil® combination of the channels as shown in equation (2).

$$S_i = \frac{I_i}{SoS} \quad (1) \quad S_i' = \frac{I_i}{E_1} \quad (2)$$

where  $S_i$  denotes the sensitivity profile of the  $i^{\text{th}}$  channel,  $E_1$  is the primary mode of the Eigen combination. This

primary Eigen mode has a profile similar to that of the transmit field of a quadrature birdcage coil. It has been observed that the combined channel, which has the biggest Eigenvalue, is more uniform than the SoS [2,3]. Thus, the sensitivity maps are now weighted by a more uniform mode and hence a more uniform reconstruction is expected. Brain images were acquired on a GE Signa 3.0T scanner, with the standard high-resolution 8-channel head coil (Invivo Corporation, Gainesville, Florida). A standard gradient recall echo (GRE) sequence was used. SENSE acquisition was simulated with a reduction factor of 3 and the center 40 lines of k-space were used as the calibration data for the computation of sensitivity profiles. The sensitivity profiles for the standard SENSE algorithm were obtained using equation (1) and normalizing with the SoS of the low-resolution images. The Eigen modes were obtained by computing the Eigen values and Eigen vectors from the correlation between the computed sensitivity maps. Our technique then uses equation (2) to compute the sensitivity profile required for SENSE reconstruction.

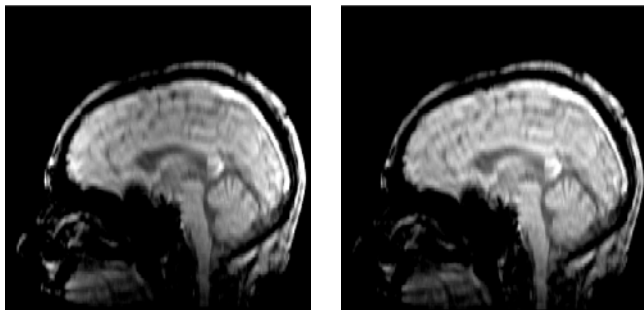


Fig. 1(a) SoS from the raw uncombined channels from low-res. image

Fig. 1(b) Primary mode from the Eigencoil® combined channels from the low-res. image

**Results:** Figure 1(a) illustrates the SoS, and 1(b) shows the primary mode of the Eigencoil® combined channels. Both images are displayed at the same intensity levels. Clearly, Fig. 1b is more uniform and more suitable for the calculation of sensitivity profiles. Figures 2(a) and (b) show the original SENSE reconstructed image and the result of the intensity correction technique used here. Note that images 2(a) and 2(b) are at the same intensity levels. Notice how the region shown by the blue box is visibly brighter in the intensity corrected image. Figure 2(c) shows a line profile through the image as shown by the green line. Notice how the red line is more leveled than the blue line that fluctuates a lot between the center and ends of the image.

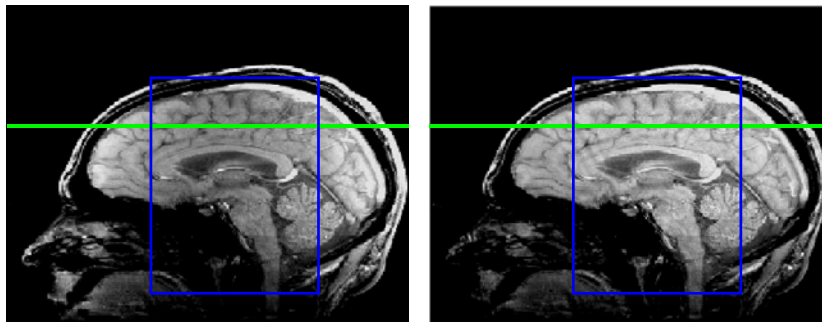


Fig. 2(a) Original SENSE reconstructed image.

Fig. 2(b) Intensity corrected image

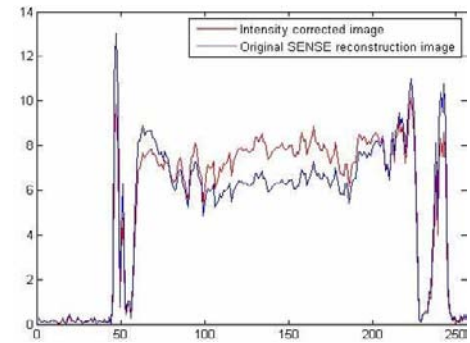


Fig. 2(c) Line profile through the image.

**Conclusion:** Eigenmode is used to improve the image homogeneity of SENSE reconstructed images. This technique is useful because it needs no extra acquisition and makes use of just the ACS line data. Thus, the use of Eigen modes in the computation of sensitivity maps produces visibly more uniform and better quality images. This technique can also be applied to non-PPI SoS reconstruction as well.

**Reference:** [1] Pruessmann et al. MRM 42:952-962 (1999). [2] King S.B. et al. Proc. ISMRM, p.712, 2003. [3] Gotshal U. et al. Proc. ISMRM, 2004.