MULTI-CONTRAST JSENSE

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TARGET AUDIENCE: Researchers and clinicians interested in highly accelerated MRI

PURPOSE: Clinical MRI usually acquires multiple contrast images in the same region of interest (ROI), such as T1 and T2 weighted. In parallel imaging, these images with different contrasts theoretically share the same coil sensitivities since the same patient is scanned in the same system using the same RF coil. Joint estimation of images and coil sensitivities, called JSENSE [1,2,3], has been shown to lead to more accurate self-calibrated coil sensitivities so that it yields images with improved quality. Since using all the calibration signals from multiple contrast images potentially provides more information of coil sensitivities, we propose to use multi-contrast information to enhance JSENSE. The same coil sensitivities and multiple contrast images are jointly reconstructed in a new model. Preliminary results demonstrated that the multi-contrast JSENSE algorithm with more accurate initialization results in images with improved quality, while costs no more computational time than original JSENSE.

THEORY: Without loss of generality, Iteratively Regularized Gauss-Newton method (IRGN) [2,3] is used as a specific implementation of JSENSE to explain the proposed method. IRGN determines one single image and coil sensitivities by solving a minimization problem:

$$\rho,\{c_j\} = \arg\min \sum_{j=1}^{Nch} \left\| F(\rho \cdot c_j) - y_j \right\|_2^2 + \alpha \left\| \rho - \rho^0 \right\|_2^2$$

where ρ is the desired image, $\{y_j\}_{j=1 \ldots Nch}$ is the under-sampled k-space data with calibration by *Nch*-channel coils, c_j is the unknown sensitivity of the j^{th} channel coil and ρ_0 is the reconstructed image in previous iteration. ρ_0 and c_j are initially set to be constant one and zero respectively in the original paper [2,3]. Based on the fact that the coil sensitivities are very similar among images with different contrasts, we propose to jointly reconstruct these images of multiple contrasts simultaneously:

$$\{\rho_i\},\{c_j\} = \arg\min \sum_{i=1}^{N} \left(\sum_{j=1}^{Nch} \left\| F(\rho_i \cdot c_j) - y_{i,j} \right\|_2^2 + \alpha \left\| \rho_i - \rho_i^0 \right\|_2^2 \right)$$

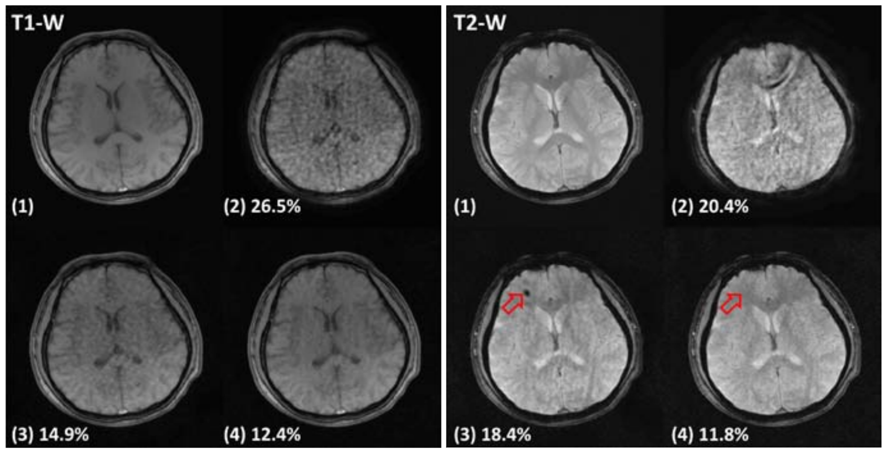

Fig.1 **(1)**Reference images from full-sampling data and reconstructed images using **(2)**IRGN **(3)**IRGN with enhanced initialization and **(4)**MC JSENSE, with RMSE shown in the form of percentage. The computational time of **(2)**, **(3)** and **(4)** are 25.1s, 20.9s and 23.1s respectively.

In the new model above, *N* contrast images are assumed to share the same coil sensitivities, such that coil sensitivities are computed with more calibration information. As for initialization, results from traditional parallel imaging (such as mSENSE [4]) instead of constant values are used. For the initialization of coil sensitivities, the calibration data from multiple contrasts are integrated in one equation system which is solved in the sense of least square. The proposed method is called MC JSENSE.

METHODS: Full-sampled in vivo brain data with T1 and T2 weighting were acquired on a Philips 3T clinical scanner (Achieva, Philips, Best, The Netherlands), by an 8-channel phased array coil (Invivo Corp., Gainesville, FL, U.S.A). T1 and T2 weighted data were artificially downsampled by multiplying the full-sampling data with a Poison Disk mask, with a calibration size of 32*32 in the center and the acceleration factor R=6 (net R=5.4). Initial T1 and T2 weighted images were obtained by mSENSE reconstruction, with the coil sensitivities estimated from calibration data of both T1 and T2 weighted in one equation.

RESULTS AND DISCUSSION: Reconstructed T1 and T2 weighted images using IRGN, IRGN with enhanced initialization and MC JSENSE are shown in Fig.1, all of which are computed after 6 Gauss-Newton iterations with similar time costs. It is observed that compared to IRGN, both IRGN with enhanced initialization and MC JSENSE result in much better images, in terms of less artifacts and lower noise level. Moreover, MC JSENSE results not only gain lowest noise level but also avoid unpredicted artifacts (see the arrows in Fig.1) in independent reconstruction, due to more accurate coil sensitivities obtained. The advantage of jointly calculated coil sensitivities is further verified by mSENSE, as shown in Fig.2.

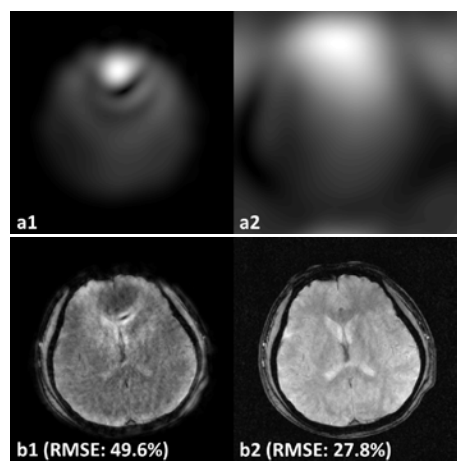

Fig.2 **a)** Computed coil sensitivity of one channel using **a1** IRGN and **a2** MC JSENSE of T2 weighted. **b)** mSENSE results using the above two coil sensitivities respectively.

CONCLUSION: A multi-contrast parallel imaging reconstruction method, MC JSENSE is proposed. Lower noise level and reduced artifacts can be achieved by the proposed method, which has potential impact to applications with a series of multi-contrast scans.

ACKNOWLEDGEMENTS: This work is supported by National Key Technology R&D Program in the 12th Five year Plan of China.

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