Improved Initialization of the Iterative Reconstruction for Sensitivity-Encoded Non-Cartesian Imaging

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A strategy for accelerating the convergence of the conjugate gradient method used to reconstruct images from sensitivity-encoded data sampled on arbitrary $k$-space trajectories is proposed. It applies the principle of localizing the coil sensitivities to the calculation of a starting image. This starting image replaces the zero image employed to initialize the conjugate gradient method so far. The required number of iterations, and with it the running time of the reconstruction, is shown to decrease thus.

**Introduction**

Recently, a fast reconstruction algorithm for sensitivity-encoded non-Cartesian imaging has been suggested [1]. It uses the conjugate gradient (CG) method to solve the occurring large linear system of equations (LSE). The efficiency of this iterative method depends on a suitable initialization. Although generally demanding an approximation of the LSE’s exact solution, a zero image serves the initialization to date. It causes a rescaled copy of the LSE’s right-hand side to result after the first iteration, which then functions as starting image. This choice ensures a proper scaling of the starting image, but is not optimal with respect to a fast convergence.

**Materials and Methods**

The number of iterations necessary to achieve a satisfactory image quality correlates with the amount of aliasing present in the starting image. It is, therefore, highly desirable to achieve a suppression of aliasing for the initialization of the conjugate gradient method. Localizing the coil sensitivities in the reconstruction has, in a different context, been shown to reduce subsampling artifacts [2, 3]. It involves restricting the contribution of each coil to an image area of predefined extent with maximal sensitivity. It proves particularly effective if the non-localized sensitivities of each coil partially and the localized sensitivities of all coils together completely cover the field of view (FoV) [3].

This principle may be applied to the initialization of the conjugate gradient method without difficulty. For higher reduction factors, however, it needs to be extended to cope with void areas arising in the starting image. This work suggests filling them with corresponding areas in the LSE’s right-hand side. In addition, it proposes to reduce subsampling artifacts in these areas by first estimating and then removing the contribution of aliasing to all concerned pixels. This requires calculating the aliasing generated by all other pixels, which essentially resembles one iteration of the conjugate gradient method.

To illustrate the benefit of this strategy, an acquisition with variable reduction factor on a segmented spiral $k$-space trajectory with variable angular speed was simulated. A virtual set of 6 circular receive coils was placed equidistantly around the circumference of a phantom for this purpose.

**Results**

Fig. 1 demonstrates the reduction of aliasing in the starting image and the accelerated convergence of the iteration achieved with the proposed strategy.

Fig. 2 illustrates how a suitable initialization is obtained in case the localized sensitivities of all coils together only partially cover the FoV. While simply using Fig. 2b instead of Fig. 2a as starting image leads to no faster convergence, a significant decrease in the required number of iterations results from filling the void central area in Fig. 2b according to the description in the caption, which yields Fig. 2c.

**Discussion**

The proposed strategy derives the starting image from the measured raw data and the estimated coil sensitivities. It does not rely on possibly available a priori information on the image content, such as previous frames in dynamic imaging, and therefore possesses a wider applicability. Its performance, however, obviously depends on the selected number of coils, the reduction factor, the positions of the coils, etc.

The principle of localizing the coil sensitivities, in particular with the suggested extension for higher reduction factors, also provides a simpler and faster non-iterative reconstruction algorithm for sensitivity-encoded non-Cartesian imaging. At the expense of image quality, the gradual improvement of the starting image may be skipped completely and the running time of the reconstruction thus be decreased substantially to satisfy, for instance, the requirements of real-time imaging applications.

**References**