Super-resolution in Single-coil Multiple Image Reconstruction Technique

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INTRODUCTION This paper presents the resolution improvement for the partially high-resolution image in multiple image reconstruction technique. The signal obtained in the phase-scrambling Fourier imaging technique can be transformed to the description of Fresnel transform equation. Therefore, an image can be reconstructed by inverse Fresnel transform reconstruction as well as by standard inverse Fourier transform reconstruction. By combining these two reconstructed images having different resolutions and field-of-view, we can obtain an image that has a higher resolution than standard imaging technique in the center of image. To improve the quality of image where resolution is the same as standard imaging technique, super-resolution technique was applied to the synthesized image, and it was shown that resolution was fairly improved by a small number of iterations.

METHODS The signal obtained in the phase-scrambling Fourier imaging technique(PSFT)[1] can be transformed to the signal described in Fresnel transform equation of the objects. So, the image reconstruction can be performed not only by inverse Fourier transform but also by inverse Fresnel transform. By giving adequate parameters in the imaging experiment, we can obtain a signal which produce a high resolution image with wraparound artifact by inverse Fourier transform, and additionally an alias-free image by the inverse Fresnel transform reconstruction. By replacing the aliasing area in the high-resolution image by Fourier reconstruction with the corresponding part in the alias-free image by Fresnel reconstruction, we can obtain an image in which central region has an improved resolution and surrounding area has the standard resolution(Fig.1 (c))[2].

To improve the resolution on the surrounding region, super-resolution based on the Gerchberg algorithm[3] is adopted. Fig.1 shows the algorithm of the procedure. The synthesized image (c) which has the image matrix of 2N×2N to ensure the improved resolution is transformed to Fresnel transform signal (g). Since the observed signal which has N×N data matrix is known at every second data in the Fresnel signal domain, those data are replaced by observed signal as true signal(d). Then the signal is inversely Fresnel transformed to reconstruct an updated image (e). In the image domain, the central high-resolution region is replaced by corresponding data on the synthesized image as true image (f). This iteration converges toward the condition that the resolution on the surrounding region equals to that on the central high-resolution region.

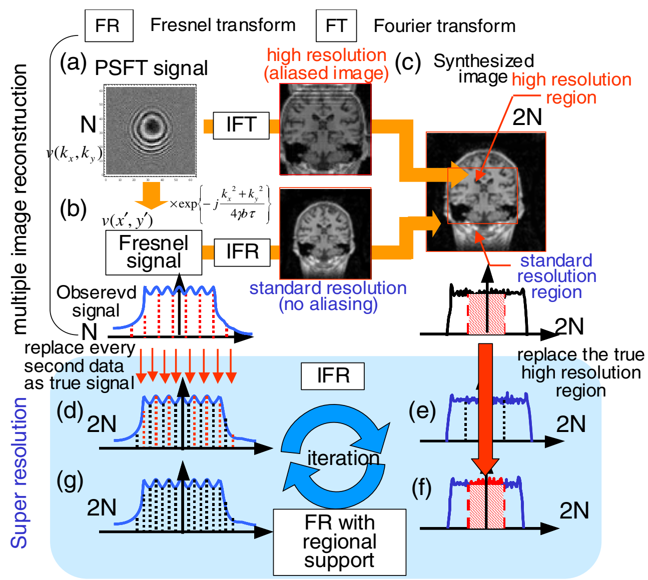

Fig.1 Super-resolution algorithm for partially high-resolution image

EXPERIMENTS Figure 2 shows the results of simulation experiments. The data matrix of the signal is 128×128, and the synthesized image is enlarged to 256×256. The central region has the resolution of 1.6 times higher than that of standard Fourier imaging. After 10 times of iteration, the resolution in the surrounding area was improved to 1.4 times by the algorithm. Proposed algorithm was also applied to the experimental data and we could recognize the resolution improvement.

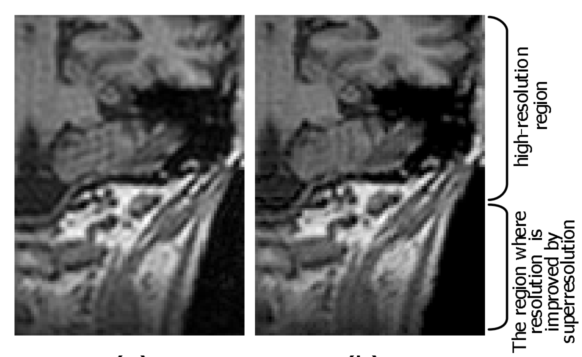

Fig.2 Results of super-resolution. (a) standard-resolution image, (b) synthesized image after super-resolution.

CONCLUSION A new resolution improvement technique for partially high-resolution image in MR multiple image reconstruction is presented and demonstrated. To improve the resolution on the standard-resolution region, super-resolution was applied. It was shown that the resolution on the surrounding region was improved to a value close to the resolution on the central high-resolution region.

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