A Solution for the Dynamic Range Problem by Means of a Parallel Image Acquisition

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Introduction

The dynamic range of MRI receiving system often become short because the MRI signal is very large only around the center of the k-space. This problem becomes serious when a 3D spin-echo image acquisition is performed at a high magnetic field [1-3]. One of the straightforward solutions to this problem is to use an intermediate frequency and direct digital sampling at the rate of several tens of MHz. This approach, however, requires complicated and high-speed data sampling and processing hardware. Another practical solution is a dual-scan technique with low-gain and high-gain data-acquisitions for the low and high spatial frequency components [4-5]. This approach, however, requires an extra scan time. In the present study, we have developed a new solution to this problem by using a parallel image acquisition.

Experiments

Figure 1 shows our experimental setup. The 400 MHz MRI signal detected at the RF coil was amplified by a preamplifier and divided into two signals. One signal was further amplified (+37dB for spin echo signal, +30dB for gradient echo signal) and put into an MRI receiver (DTRX4, MRTechnology). Another signal was directly put into another receiver. Both quadrature-detected MRI signals were digitized simultaneously using two 14-bit 2CH ADC boards (DATEL, PC-414G3, USA) installed in a PC running under Windows 98 operating system.

The dataset for image reconstruction was synthesized from the two datasets simultaneously digitized: low and high spatial frequency components were picked up from the datasets sampled with low-gain and high-gain receivers. Gain adjustments were performed through complex number operation of two receiver signals. A water phantom and chemically fixed human embryos were used to demonstrate the effectiveness of our method.

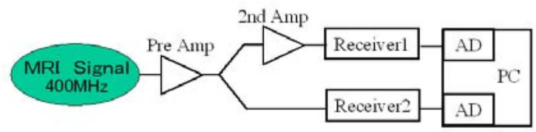

Fig.1 Parallel image acquisition system

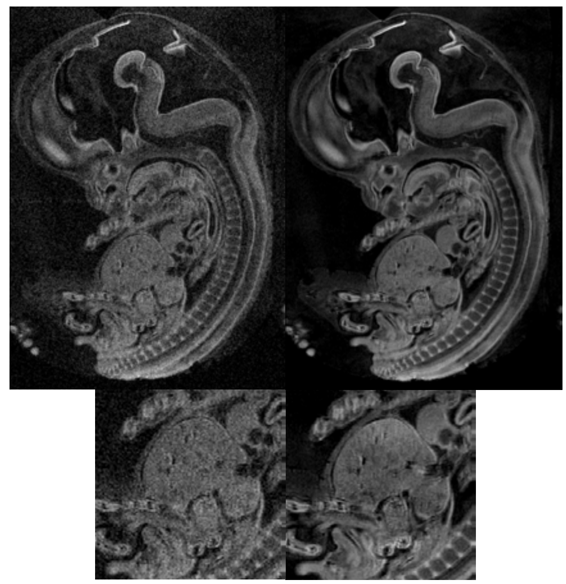

Fig.2 Mid-sagittal cross sections selected from 3D image datasets of a chemically fixed human embryo acquired with a 3D gradient echo sequence. Left: single channel (low gain) image. Right: dual channel (synthesized) image.

Results

Figure 2 shows mid-sagittal cross-sections of a Carnegie Stage 22 human embryo acquired with a 3D gradient echo sequence (TR=100ms, TE=5ms, image matrix: 256×256×512, 60μm^3 voxel) using a 9.4 T MR microscope system developed in our laboratory. The left figure shows the image reconstructed from the dataset acquired with the low-gain channel. The SNR at the spinal cord is about 8.2. The right figure shows the image reconstructed from the synthesized dataset. The SNR at the spine is about 26. We also obtained similar but more drastic result on the 3D spin echo sequence(SNR at the spinal cord was 4.4 for the single channel and 26 for the dual channel). These results clearly demonstrate the effectiveness of our method.

Discussion and Conclusion

As shown in Fig.3, although the dynamic range of our single MRI receiver is about 60 dB, the total dynamic range was able to be extended up to 81dB for spin-echo images and 75dB for gradient-echo images. The dynamic range of these values is sufficient for 60μm^3 spatial resolution and the matrix of 256×256×512. In conclusion, our approach is a simple and efficient solution for the dynamic range problem in MRI.

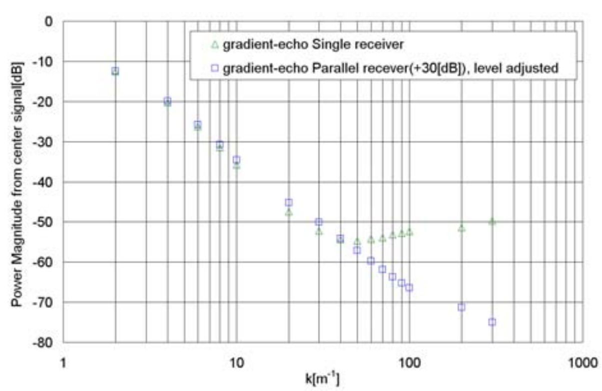

Fig.3 k-space radius versus power of MRI signal in human embryo scan.

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