[SY14] MRE Symposium ll

SY14-01

High-field MRI magnet technology

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The resolution and the sensitivity of MRI depend on the magnetic field strength. Therefore major MRI magnet manufactures tried to increase the magnetic field strength. Magnet technologies for high-field MRI are described.

Keywords : High-field MRI, Magnet, Magnetic field strength

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SY14-02

Gradient Chain in MRI System

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The discovery of nuclear magnetic resonance has been used in various fields ranging from scientific research tools, medical imaging, and quantum computing. In order to generate nuclear magnetic resonance, a homogeneous magnetic field is required, and inhomogeneity causes the phase difference between nuclear spins, resulting in signal attenuation. On the other hand, if the magnetic field is intentionally applied spatially and non-uniformly, the diffusion characteristics of the sample can be known. Furthermore, if a gradient magnetic field is applied to the region of interest, the magnetic field can be used for the imaging of the sample by the spatial encoding of the sample. The systematic application of the gradient magnetic field thus corresponds to the main function of the MRI system. In this tutorial, this generating system of the gradient magnetic field is defined as the Gradient Chain, from a pulse sequence manipulation code to a gradient coil block as a chain link. The physical principles and the implemented engineering techniques are described for each functional block in the chain. It also introduces the latest technologies and safety related issues such as peripheral nerve stimulation by dB/dt.

Keywords : Gradient Chain, Gradient Magnetic Field, Gradient Pulse Generator, Gradient Amplifier, Gradient Coil

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SY14-03

RF coil implementation

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The quality of the diagnostic images obtained by the ultra-high magnetic fields (UHF) used for human brain magnetic resonance imaging (MRI) is affected by certain phenomena such as contrast differentiation and magnetic resonance (MR) signal variance in the brain imaging area. Such phenomena are produced by the heterogeneous magnetic flux ($|B_1|$) field distortion caused by inaccurate phase delay of the radiofrequency (RF) coil. The non-uniform $|B_1|$ field distribution mainly depends on the relatively shortened RF wavelength, which is also determined by the RF wave interaction with the imaged subject. It is characterized by high dielectric constants, namely, the permittivity (εr) and conductivity. This means that the UHF RF coil does not solely determine the |B1| field distribution, and that the coil design is significantly defective with respect to homogenous RF transmission ($|B_T|$) and high-RF reception ($|B_R|$) sensitivity. Nevertheless, the UHF MR scanner has been continuously recommended because of its high MR signal, which is because the signal-to-noise ratio (S/N) theoretically increases with increasing main magnetic field (B_0) strength. To achieve a high signal-to-noise ratio (SNR), as well as sufficient signal homogeneity in UHF MRI, the RF coil has to be precisely designed by using the computational simulation. The geometry of the RF coil is determined based on its ability to successfully access the target region-of interest (ROI).

Keywords : Magnetic resonance imaging, Radio-frequency, Transmission, Reception, Coil

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SY14-04

Simultaneous Multi Slice Imaging Technique for Radial Trajectory Using Inter-slice Shifting Gradient

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Introduction

Simultaneous multi-slice (SMS) imaging techniques were developed to reduce imaging time without the loss of signal to noise ratio (SNR) by using the multi-band RF pulses. In SMS imaging techniques, the efficient utilization of sensitivity information in all spatial directions could increase the quality of reconstructed images. Thus, the phase modulated RF pulses[1], blipped gradients[2], or inter-slice shifting gradients[3,4] were designed to use the sensitivity information in all spatial directions. They were expanded to a non-Cartesian trajectory to combine the benefits of the non-Cartesian trajectory with the SMS imaging techniques[5], which used alternating RF phase for each radial to increase the reconstruction efficiency of multi-slice images. In this work, we proposed a new SMS imaging technique for radial trajectory using inter-slice shifting gradient, which could shift simultaneously acquired slices in any directions by adjusting the offset of cosine modulation function, thereby increases the sampling efficiency of a radial trajectory.

Methods

The multi-slice image generation using intra-slice parallel imaging and inter-slice shifting (MAGGULLI) utilized inter-slice shifting gradient, thereby shift acquired slices into readout direction. In radial trajectory, the magnitude of inter-slice shifting gradient is modulated by the radial view angle, to constantly maintain the amount spatial image shift (Fig. 1). The direction of slice shift by the inter-slice shift gradient is fixed in readout direction in Cartesian Trajectory, but in radial trajectory, we can shift simultaneously acquired slices in desired direction by change the phase of cosine modulation function.

Results

Phantom and in-vivo experiments were performed at a 3.0T MRI system (Siemens Magnetom Verio, Erlagen, Germany) with a 12 channel head coil. Phantom images were acquired using the following parameters; field-of-view (FOV) = 256 × 256 mm^2, slice thickness = 5 mm. In-vivo images were acquired with the same parameters of phantom experiments. As shown in Fig. 2 the proposed method could shift simultaneously acquired slices along the selected direction by adjusting the offset of cosine modulation function.

Discussion & Conclusion

In radial trajectory, filed of view (FOV) is determined by the density of radial spokes. To reduce image artifacts from eddy currents, constant increase of radial angle is used to conduct radial sampling, which reduces sampling efficiency when acquire images from the objects with an anisotropic FOV (peripheral, abdomen, etc.). In the proposed method, the simultaneously acquired slices can be shifted in any directions by adjusting the phase of cosine modulation function. In addition, the proposed method can be combined with radial-CAIPI[5] to further increase the quality of reconstructed images.

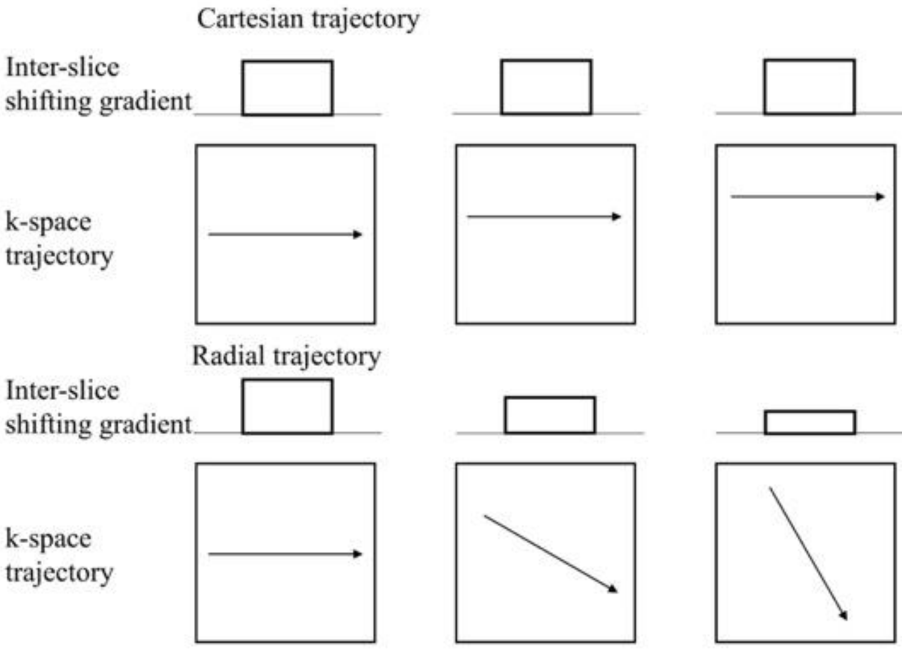

Figure 1. Schematic diagram of SMS imaging using inter-slice shifting gradient in a Cartesian and a radial trajectory.

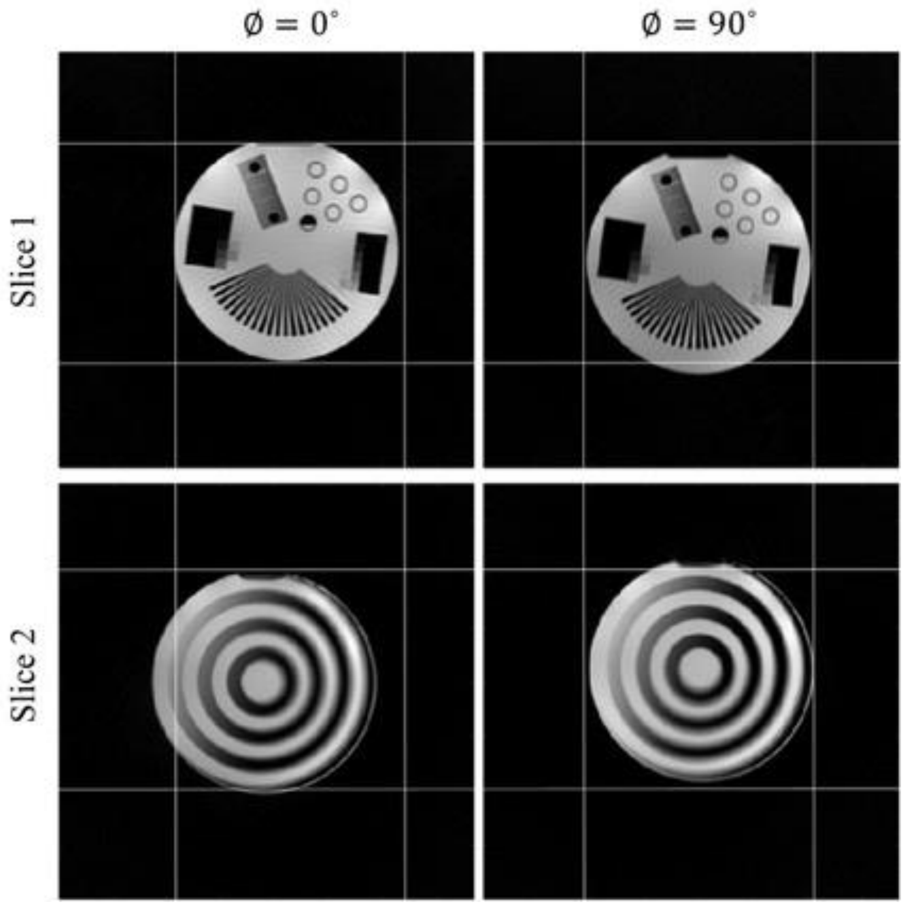

Figure 2. Experiment results of phantom with 0° and 90° offsets of cosine modulation. White lines were illustrated to show the shifts of each slice.

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Keywords : SMS imaging, Radial trajectory