Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **3279** Type: **Oral Competition (Graduate Student) / Compétition orale (Étudiant(e) du 2e ou 3e cycle)**

(G*) Optimized Phase Cycling for Coherence Pathway Cancelation in Magnetic Resonance Imaging

Monday 6 June 2022 11:45 (15 minutes)

Magnetic Resonance Imaging (MRI) is a non-invasive imaging modality which provides excellent soft tissue contrast. An MR echo signal can be generated by an excitation and a refocusing radiofrequency (RF) pulse, where spatial encoding is achieved by applying magnetic field gradients that create signal phase evolution at different spatial locations. A train of echoes can be generated with multiple refocusing RF pulses to acquire images more rapidly. However, non-ideal refocusing RF pulses result in multiple coherence pathways in the echo signals, leading to image artifacts.
The Rapid Acquisition with Relaxation Enhancement (RARE) method used crusher gradients to remove the unwanted coherence pathways. Balanced imaging gradients within each echo interval were employed for a net zero phase evolution due to spatial encoding gradients. The high amplitude gradient pulses limit the echo spacing which affects the MRI image contrast, resolution and signal-to-noise ratio. High levels of gradient switching can reduce image quality, create acoustic noise, and cause peripheral nerve stimulation. In this work, we propose to employ RF phase cycling to eliminate the coherence pathway artifacts and reduce the magnetic field gradient duty cycle. The phase cycling schemes were determined through an optimization procedure. The method was applied to both 2D and 3D imaging sequences and compared to conventional balanced RARE sequences.

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Session Classification: M1-3 Imaging - MRI (DPMB) I Imagerie - IRM (DPMB)

Track Classification: Technical Sessions / Sessions techniques: Physics in Medicine and Biology / Physique en médecine et en biologie (DPMB-DPMB)