Inhomogeneity Insensitive MSDE (i2MSDE)

Jinnan Wang[1], Michael Schär[2], Chun Yuan[3], and Peter Börnert[4]

[1]*Philips Research North America, Seattle, WA, United States,* [2]*Philips Healthcare, Cleveland, Ohio, United States,* [3]*University of Washington, Seattle, WA, United States,* [4]*Philips Research Europe, Hamburg, Hamburg, Germany*

Introduction: Motion Sensitized Driven Equilibrium (MSDE)[1] was originally proposed to achieve satisfactory blood suppression in vessel wall applications. The iMSDE technique was later on found to provide improved image quality at the presence of systemic imperfections, such as B_1 inhomogeneity and eddy currents, compared to the traditional MSDE sequence[2]. With the gaining popularity of large coverage 3D black blood imaging, iMSDE images were also frequently found to present severe signal drop and banding artefacts. This is particularly notable at locations with severe system inhomogeneities, such as the peripheral of FOV in large coverage imaging volumes. Encouraged by recent developments for flow velocity filters in ASL applications[3,4], the purpose of this study is to propose and test an inhomogeneity insensitive MSDE (i^2MSDE) sequence for black blood imaging that's even less sensitive to B_1/B_0 imperfections than the iMSDE technique.

Methods: The i^2MSDE pulse sequence diagram and imaging parameters are shown in Fig.1. It achieves the elevated robustness against field inhomogeneity by inserting motion sensitizing gradients into a B_1 insensitive rotation (BIR-4) adiabatic pulse[5]. Assume an ideal gradient waveform, the magnetization (M_z/M_0) level was calculated at different B_1/B_0 combinations for the i^2MSDE pulse, by using numerical simulation of the Bloch equation. A similar simulation was also made for the iMSDE pulse sequence. All MR experiments were conducted on a 3T scanner (Philips Achieva R3.21). In the phantom experiment, a $CuSO_4$ solution phantom with known T_1/T_2 of 425/340ms was scanned by both sequences using matched m_1 values (~1500mTms^2/m). Both coronal and axial scans were obtained. The carotid artery of a healthy volunteer (25 M) was scanned by both sequences using matched m_1 and acquisition parameters to examine the robustness of both techniques against systemic imperfection. Detailed imaging parameters are: TSE, TR/TE 1100/10ms, TSE factor 12, FOV 160×160mm, Thickness 2mm, Fat Saturation.

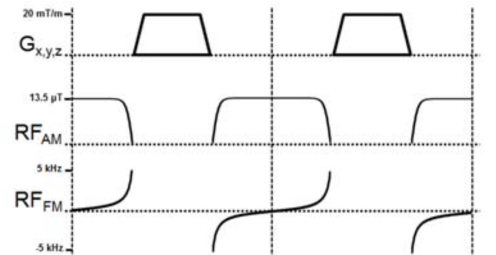

Fig. 1 Pulse sequence of the i^2MSDE technique. Adiabatic BIR-4 pulse was used to achieve excitation across regions with field inhomogeneities.

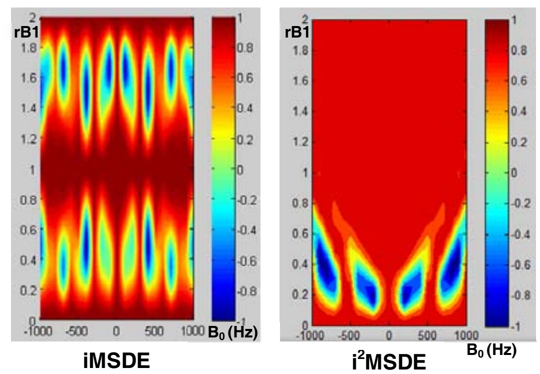

Fig. 2 Bloch simulation for magnetization (M_z/M_0) at different field inhomogeneities: comparison between iMSDE (left) and i^2MSDE (right) pulses.

Results and Discussion: As shown in Fig.2, the numerical simulation demonstrated that the i^2MSDE sequence is more robust against systemic imperfections when compared to the iMSDE. In the phantom experiment, the banding artifacts shown on the iMSDE image at the peripheral of the phantom were completely removed on the i^2MSDE images, both on coronal and axial views. For the in vivo comparison, similar results were found. Although the image quality for both techniques was comparable for locations near the center of the magnetic field, severe banding artifacts were found on iMSDE images while not found on i^2MSDE images. A quantitative lumen SNR comparison shows no difference between the two techniques.

Conclusion: In this study, an inhomogeneity insensitive MSDE (i^2MSDE) sequence was proposed to provide robust black blood image quality for large coverage black blood imaging applications. The i^2MSDE sequence was found to provide more robustness against systemic imperfection than iMSDE, through both numerical simulation and phantom experiments. Notable image quality improvement was also found on the in vivo experiments, especially at locations far away from the iso-center of the scanner.

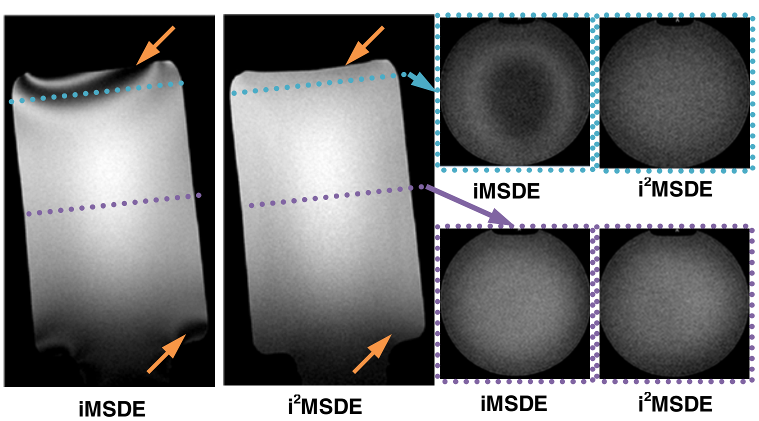

Fig. 3 Phantom experiments comparing the performance of the two sequences. At the periphery of the phantom, obvious artifacts were found on iMSDE, but not i^2MSDE images (arrows). Cross-sectional images show that although the two perform similarly at the center of the phantom (purple), significant artifacts can be found on iMSDE at the periphery (cyan).

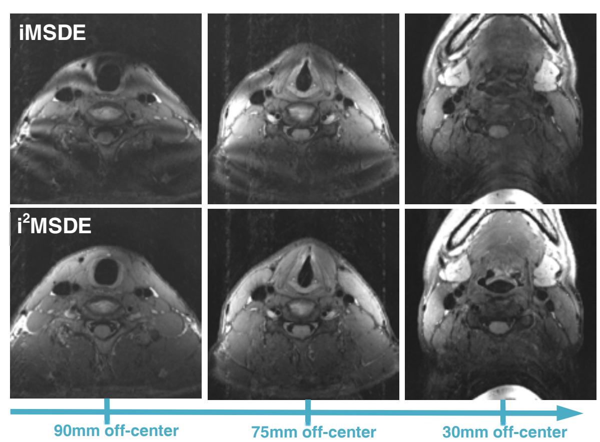

Fig. 4 In vivo comparison between iMSDE (top row) and i^2MSDE (bottom row) images. More artifacts were found on iMSDE images at locations further away from the iso-center, while i^2MSDE provided satisfactory image quality across all locations.

References: 1. Wang J et al. MRM 2007; 58:973. 2. Wang J et al. JMRI 2010; 31:1256. 3. Wong EC et al. ISMRM annual meeting 2010, #2853. 4. Meakin JA et al. ISMRM annual meeting 2012, #576. 5. Garwood et al. JMR 1991; 94:511.