Assessing generalized multi-pool exchange tissue model MRI simulations for the modelling of an ultra-low field scanner

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Hypothesis

- Ultra-low field (ULF) MRI scanners are expected to be a valuable tool for the triage of patients due to their low costs
- Simulations of ULF MRI scanners would be useful in helping to determine whether they can provide the information necessary for triage
- We have developed and tested software for creating such simulations and found them to be representative of ultralow field acquisitions

Methods

- The ULF scanner described by Sarracanie et al., [1] was simulated using MRiLab [2]
- MRiLab was also used to model the bespoke wound litz coil used by the ULF scanner to improve signal
- Gaussian sampling of half of the k-space, used for the ULF k-space acquisition, was applied post-simulation
- The reconstructed simulation was filtered using the MATLAB implementation of the Perona-Malik filter
- Relaxation values at ULFs were extrapolated based on historical MR data [3]
- An acquisition of a resolution phantom on the ULF MRI scanner was used for qualitative and quantitative comparison. The latter was performed using the signal-to-noise ratio (SNR), defined as mean over the phantom area vs. standard deviation of the background

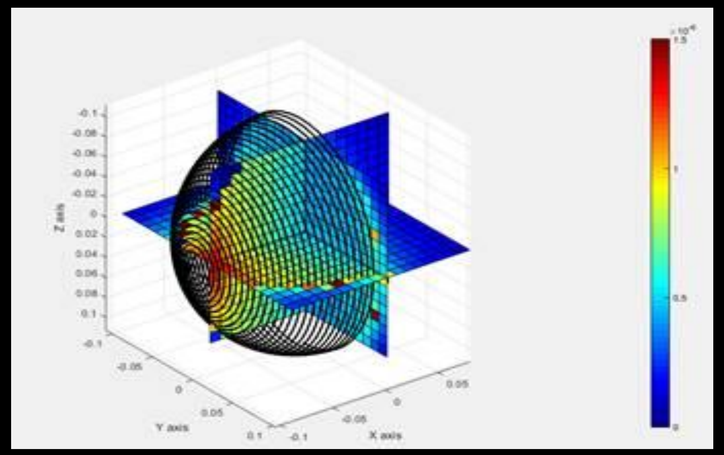

Figure 1: MRiLab model of the bespoke ULF coil

Results

- The bespoke coil modelled showed an appropriate sensitivity distribution (figure 1)
- Qualitative comparison shows that images appear visually similar (figure 2)
- The SNR of the simulated brain is 21.9, which is slightly higher than the value calculated for the resolution phantom, which is 19.2

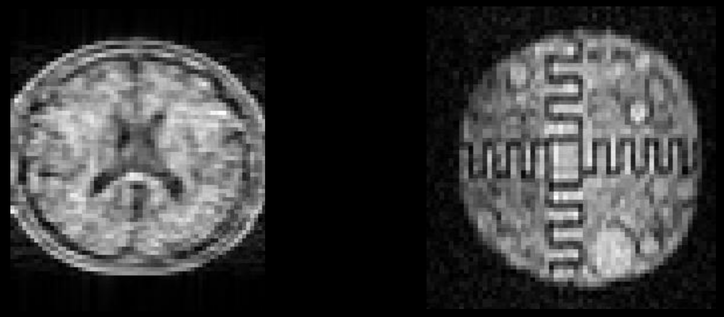

Figure 2: Left: ULF simulation of a brain scan. Right: ULF acquisition of a resolution phantom

Conclusions

- There is a slight SNR difference, which could be due to how noise is applied in the simulation or differences in filtering
- Simulations using MRiLab provide value even for ultra-low field investigations and can be used for testing hypotheses in less time and more cheaply than physical investigations
- A next step would be further validation by e.g. simulating and measuring the same standard object and quantitively analysing the results.

Acknowledgements

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[1] Sarracanie, M. et al. Low-Cost High-Performance MRI. Scientific Reports 5, 15177 (2015). [2] Liu, F., Velikina, J. V., Block, W. F., Kijowski, R. & Samsonov, A. A. Fast Realistic MRI Simulations Based on Generalized Multi-Pool Exchange Tissue Model. IEEE Transactions on Medical Imaging 36, 527–537 (2017). [3] Rooney, W. D. et al. Magnetic field and tissue dependencies of human brain longitudinal H2O relaxation in vivo. Magn. Reson. Med. 57, 308–318 (2007).