Quantification of cardiac fat infiltration and T2* relaxation using ultra-high magnetic fields and machine learning based RF calibration.

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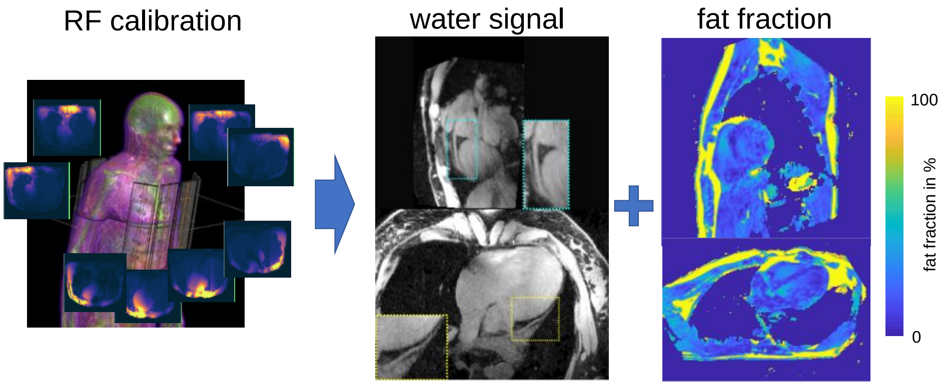
Theme: Tissue structure

Background: Ultra-high field (UHF) MRI operating at 7 Tesla and higher offers higher signal-to-noise ratio, better separation of metabolites or fat peaks and often stronger contrast, e.g. T2* contrast, compared to clinical field strength of 1.5 Tesla or 3 Tesla. However, the short RF wavelength causes heterogeneous transmit fields (B1+) in the human body at that high field and thereby generates substantial contrast variations and localized signal voids. This effect also impacts the accuracy for quantitative MRI techniques. To address the variations and signal voids, 3D parallel transmission techniques will be developed in this work in combination with very fast deep learning based B1+ mapping techniques.

Hypothesis: Ultra-high field (UHF) enables a stronger contrast for T2* imaging for myocardial tissue characterization as well as improved quantification of the fat composition.



Methods: In this work a machine learning based field mapping technique will be extended based on preliminary work for mapping the B1+ fields across the human heart (1). This will enable parallel transmission techniques for a homogeneous excitation for fat and water resonance frequencies across the heart at 7 Tesla. Furthermore, the separation of multiple fat peaks will be enabled by extending a 3D cardiac fat / water imaging acquisition (2) with the aim is to quantify the individual fat components. Furthermore, the method will ultimately allow for quantitative 3D T2* mapping in the human heart. The tools and the acquisitions will become part of a routine protocol, that will be applied in a patient cohort at 7 Tesla in the last part of this project.

Collaboration: The project will be performed in close collaboration between Prof. Schulz-Menger and her group at Charité hospital and Dr. Schmitter and his group at PTB. The students will join our joint project meetings as well as our regular joint group meetings for discussions, presentations, and feedback. Furthermore, the project will be strongly linked to the group of Dr. Kolbitsch at PTB, particularly concerning the image reconstruction.

Impact: The development will allow for 3D myocardial T2* quantification as well as for quantification of the fat composition. This will enable accurate myocardial tissue characterization and potentially the detection of iron deposition after myocardial infarct.

References:

1. Dietrich S, Aigner CS, Kolbitsch C, Ludwig J, Mayer J, Schmidt S, Schaeffter T and Schmitter S. “3D Free-breathing Multi-channel absolute B1+ Mapping in the Human Body at 7T”, Magn Reson Med. 2021 May;85(5):2552-2567.
2. Dietrich S, Aigner CS, Mayer J, Kolbitsch C, Schulz-Menger J, Schaeffter T, Schmitter S. "Motion-compensated fat-water imaging for 3D cardiac MRI at ultra-high fields", Magn Reson Med. 2022 Jun;87(6):2621-2636

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