Real-Time Water-Fat Separation

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Target Audience: This abstract is for scientist interested in fast imaging or water-fat separation or both.

Purpose: The presented study extends the static water-fat separation to real-time imaging.

Methods: Data acquisition was performed on a Siemens Tim Trio 3T scanner with a multi-echo radial FLASH[1] sequence, using different commercial coils. Imaging parameters were optimized for a short acquisition time. The base resolution was either 128, 256 or 320 at in-plane resolutions varying from 0.75-2mm. TR/TE and bandwidth varied from $TR/TE_1/TE_2/TE_3$=3.92/1.29/2.25/3.21ms to $TR/TE_1/TE_2/TE_3$=6.62/2.10/3.78/5.46ms and 810-1950 Hz/pixel and flip angle was 12°. Determined by the number of spokes ranging from 13-31, the temporal resolution ranges from 51-250ms. All data was acquired during free breathing.
For image reconstruction we used a regularized nonlinear inverse (NLINV)[2,3] reconstruction after which an initial phase constrained multi-peak iterative decomposition of water and fat with echo asymmetry and least squares estimation (IDEAL)[4,5,6] was performed. For each frame the field map was initialized using the median filtered field map from the previous frame, except for the first frame, where the region growing IDEAL[7] was used. The whole process is completely integrated into the scanner and runs fully automatic.

Results:

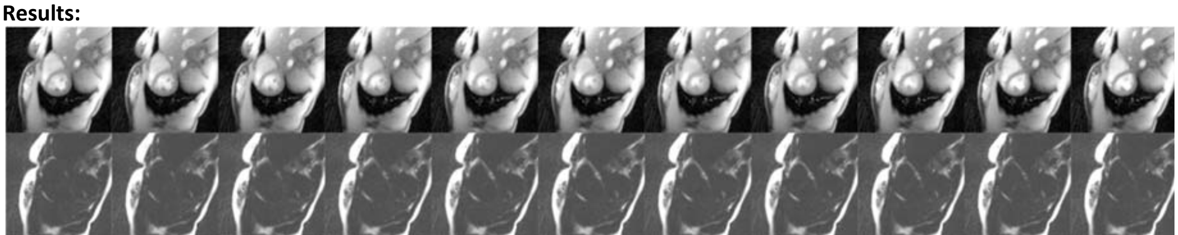

Figure 1: Water-fat time series of a human heart with a temporal resolution of 51ms. Upper row depicts water and lower row fat.

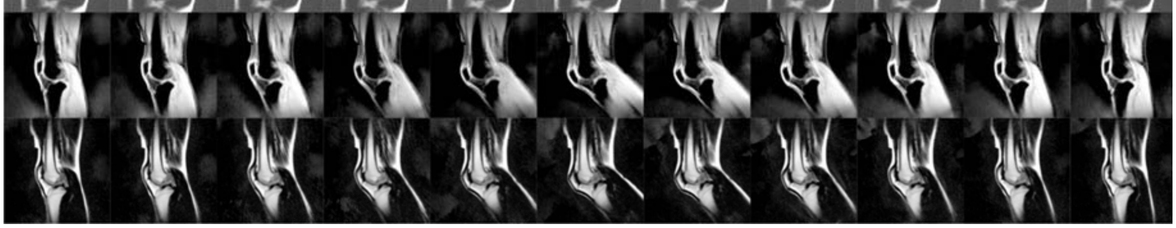

Figure 2: Knee water-fat time series with a temporal resolution of 250ms, every 8th image is displayed. Upper row depicts water and lower row fat.

Discussion: We showed that real-time water-fat separation is possible with a decent spatial resolution. The noise in the NLINV reconstructed images increases as the undersampling and therefore the temporal resolution increases, but the IDEAL algorithm is robust in low SNR images and capable of estimating and propagating the field map. Both are crucial aspects for real-time imaging. The implemented filtering approach for the field map is able to correct false identified pixels after a transient time.
The image quality of the water-fat images if separated correctly depends on the echo times[8] and the image reconstruction[2,3]. Therefore a model based approach will probably improve the image quality.
IDEAL offers the opportunity for T2* estimation[5], which accuracy increases with the number of echoes at the trade-off of temporal resolution. Moreover this method can then serve as a basis for real-time fat quantification if T2*, T1 and noise bias effects are properly corrected.

Conclusion: Real-time water-fat separation with almost up to 20 frames per second is feasible.

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