Adaptive Iterative T2 Mapping with Maximum Pearson Correlation in the Presence of Noise

S. W. Anderson[1], J. A. Soto[1], O. Sakai[1], and H. Jara[1]
[1]Radiology, Boston University Medical Center, Boston, MA, United States

Purpose: The current gold standard multi spin-echo acquisition for T_2 qMRI is a CPMG pulse sequence with 32 echoes (1). However, the optimum number of echoes for T_2 qMRI mapping can be tissue dependent and also depends on noise level and inter echo spacing. The purpose of this work was to develop a T_2 qMRI algorithm such that the number of echoes used for semi-logarithmic regression is adaptively and iteratively determined on a pixel-by-pixel basis for maximum pixelwise Pearson correlation.

Experimental Methods: Imaging experiments were conducted using an 11.7 Tesla vertical bore MRI scanner (Bruker BioSpin, Billerica, MA). Images were acquired with a multi spin-echo CPMG pulse sequence with the following parameters: TE1=6.4ms, echo spacing=6.4ms, number of echoes=32, slices=16 and TR=4000ms. A 20mm in diameter transmit/receive quadrature RF-coil was used to image a mouse liver specimen, which was placed in 15 mm glass vials along with smaller vials (6 mm diameter) containing both PBS (free from contamination related to the specimens) and olive oil to provide absolute aqueous and lipid T_2 references. The sample was temperature-controlled and all imaging was performed at 22.5±1°C.
The adaptive iterative T_2 qMRI algorithm was programmed using Mathcad (PTC, Needham, MA). The principle of operation of the adaptive iterative T_2 qMRI algorithm is illustrated in ***Fig*** 1. In the first step the algorithm is programmed to calculate maps of T_2 and the Pearson correlation coefficient (R^2) using only echoes up to $3T_2$ of the shortest expected T_2 in the image, in this case 90ms. In general, the T_2 values at this point will be close to the true T_2s but the correlation coefficients will not be optimized particularly for long T_2 species. In a second computational step, the algorithm calculates the optimum number of echoes for every pixel based on the condition: $TE_{opt}=1.25\ T_2$. In a third step, the algorithm calculates the final T_2 maps and also map of the second iteration correlation coefficient.

Results: As shown in the signal-to-echo-time semi-logarithmic plot (***Fig.*** 1 bottom), for pixels of the liver specimen, the optimum number of echoes for T_2 calculation is much less than 32 because the last 21 echoes are at or near the noise level. However, the optimum number of echoes (not shown) for PBS and olive oil in the inner reference vial is 32. Typical image quality of the T_2 maps is illustrated in ***Fig.*** 2 (top left): note that the finer details the liver vasculature are clearly preserved and that the whole-liver T_2 histogram is gaussian and symmetric, centered at 30ms. The Pearson correlation coefficient map (***Fig.*** 2, top right) is near unity for all MR active pixels and exceed R^2 of 0.96 as shown in the surface plot (***Fig.*** 2 bottom right). Other measured peak T_2 values for the whole-sample histogram are: 89ms (olive oil), 314ms (contaminated PBS), and 395ms (pure PBS). The processing time for 16 slices --256x256 matrix size-- was 90s.

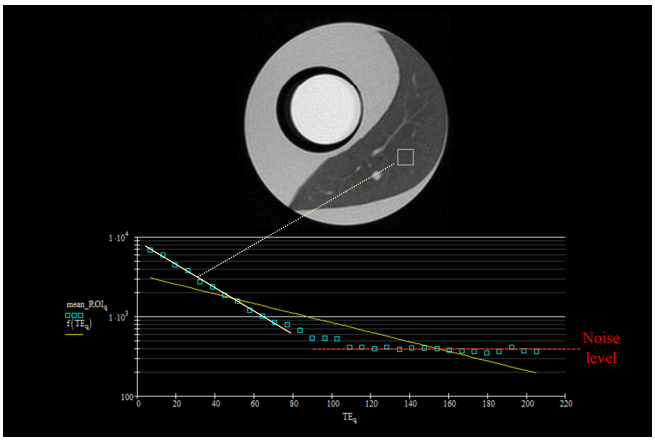

Figure 1:

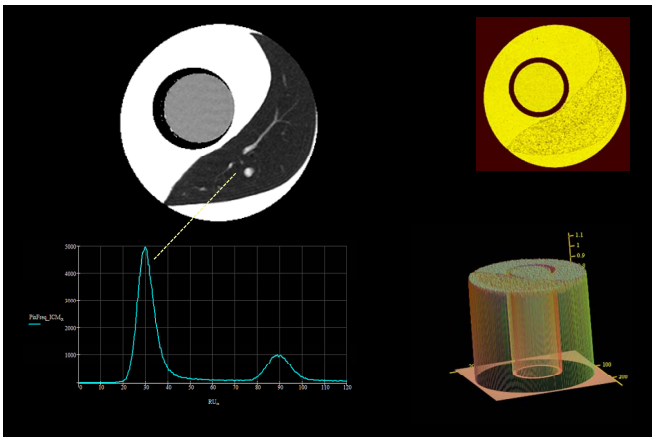

Figure 2:

Conclusion: An adaptive and iterative qMRI algorithm for mapping T_2 with an optimized number of echoes for every pixel has been developed. *In vitro* results at 11.7T show that T_2 maps with excellent image quality can be generated and with better than 0.96 Pearson correlation coefficient for all pixels. To the best of our knowledge, this is a new approach to T_2 qMRI in the presence of noise and should be considered as a valid alternative to the most used algorithms (2). This algorithm could be useful for monitoring subtle T_2 changes caused by disease in animal models and also for processing *in vivo* CPMG data (3).

References

1. Whittall KP, MacKay AL, Li DK. Are mono-exponential fits to a few echoes sufficient to determine T2 relaxation for in vivo human brain? Magn Reson Med 1999;41(6):1255-1257.
2. Raya J, Dietrich O, Horng A, Weber J, Reiser M, Glaser C. T2 measurement in articular cartilage: Impact of the fitting method on accuracy and precision at low SNR. Magnetic Resonance in Medicine 2010;63(1):181-193.
3. Roebuck JR, Haker SJ, Mitsouras D, Rybicki FJ, Tempany CM, Mulkern RV. Carr-Purcell-Meiboom-Gill imaging of prostate cancer: quantitative T2 values for cancer discrimination. Magn Reson Imaging 2009;27(4):497-502.