Emulating T2 Weighted MRI Data using T1 Maps and Susceptibility from STAGE Imaging

Abstract No:

1490

Submission Number:

1490

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Purpose:

Clinical MRI has a growing need for fast quantitative brain imaging protocols. Many have been proposed and each has limits to the quantitative information it can provide. For those that provide maps of T1 and susceptibility (Δχ) without T2 weighted imaging (T2WI) data, successfully emulating T2WI data may reduce total patient imaging time. The purpose of this work is to show how a T1 map, already very similar in contrast to a T2W image, can be further modified using Δχ to simulate high iron content regions comparable to conventional T2WI.

Materials and Methods:

While relaxation times of biological tissues have a complex dependency on microstructure, there is still a general positive correlation to water content [1]. From the T1/T2/PD values of WM/GM/CSF, Table 1 shows why these tissues already look similar between a T1 map and T2WI data (see predicted values). While this works out nicely, iron also affects signal by decreasing T2. To compensate, a Δχ based weighting can be imposed on the T1 map to make iron rich regions and veins more comparable to T2WI data.

Five cases from a previous study were used for analysis. Imaging was performed on a 3T GE Signa scanner. T2WI data was acquired sagittal with a 3D FSE sequence at 0.67x0.67x0.7mm3 and TE=109.5ms. T1 and Δχ maps were calculated using STAGE [2], acquired axial at 0.67x0.67x2mm3. The final emulated data was calculated by multiplying the T1 map with a Δχ weighted mask (see eqns 1 & 2 in [3], n=2). The CNR relative to WM of CSF, cortical GM, red nucleus (RN), and FLAIR lesions were compared between emulated and true T2WI data.

Results:

CNR results are shown in Table 2. While CSF, cortical GM, and RN CNR are higher in the emulated data, the lesion CNR is about 2 times higher in the true T2WI data (see Figure 1). While some of the major arteries do have a shorter effective T1 from the time of flight effect, it is not always enough to match what is seen in the T2WI data (see Figure 1). This could possibly be fixed by tracking the arteries in the original STAGE data. Increased perivascular spaces are seen in the T2WI yet missed in the emulated data. This is likely due to the 3x larger voxel volume. A possible demyelinating lesion appears dark in both the emulated and true T2WI data (see Figure 1).

Conclusions:

While a more rigorous analysis would be needed to validate the diagnostic capabilities of emulated T2WI data, this work shows promise in that the major brain tissue contrasts are comparable to the conventional T2WI scan.

Categories:

ADULT BRAIN, Imaging Techniques, MRI

Assumed Tissue parameters				Predicted /CSF		Actual /CSF	
	T1 (ms)	T2 (ms)	PD	T1	$PDe^{(-TE/T2)}$	T1	T2WI
WM	900	70	0.71	**0.20**	**0.15**	**0.18**	**0.18**
GM	1600	100	0.81	**0.36**	**0.28**	**0.30**	**0.29**
CSF	4500	2500	1	**1**	**1**	**1**	**1**

Table 1: WM and GM signals relative to CSF predicted from the listed assumed tissue parameters and measured from the actual and emulated data (averaged over 5 cases). The predicted and actual values are within 20%. The emulated and true T2WI values are within 4%.

	Emulated T2W						True T2W					
	reference		CNR				reference		CNR			
case	WM (ms)	σ_{WM}	CSF	GM	RN	lesion	WM	σ_{WM}	CSF	GM	RN	lesion
1	804.9	41.6	71.1	14.3	-7.7	11.3	108.0	8.7	44.7	8.4	-6.7	16.3
2	846.3	51.9	73.4	11.4	-6.2	10.8	103.8	7.9	58.9	7.4	-4.5	23.5
3	801.6	48.3	78.3	8.2	-6.3	7.3	148.9	9.6	64.0	6.4	-2.2	14.3
4	847.3	51.0	85.1	9.5	-8.0	15.5	93.4	8.6	57.0	7.9	-5.1	27.8
5	816.5	55.5	64.8	9.1	-6.2	4.4	134.0	9.4	69.7	7.0	-5.3	11.6
Average	**823.3**	**49.7**	**74.5**	**10.5**	**-6.9**	**9.8**	**117.6**	**8.8**	**58.9**	**7.4**	**-4.8**	**18.7**

Table 2: CNR of different tissues relative to WM for five different cases from both emulated and true T2WI data.

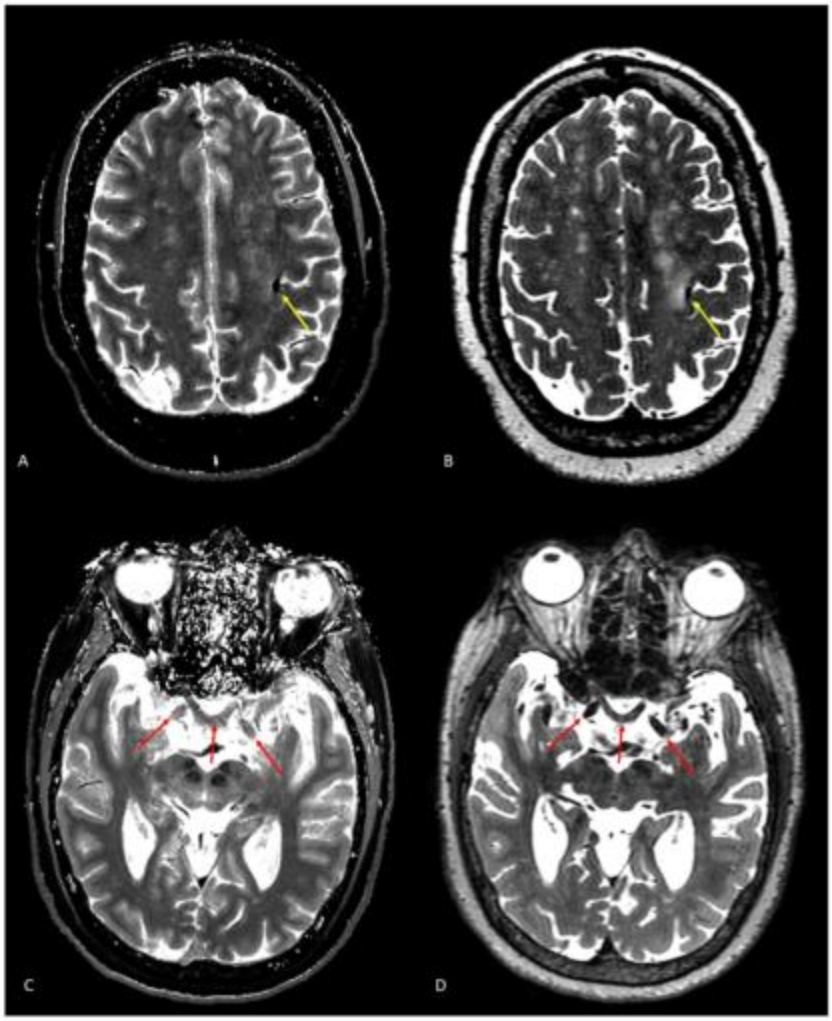

Figure 1: Slices of (A,C) emulated T2WI data and (B,D) true T2WI data from cases (A,B) #1 and (C,D) #5. The red arrows are pointing to the difference in arterial appearance. The yellow arrows are showing the similar appearance of a possible demyelinating lesion. Other lesions can be seen in the same slice and the higher contrast in the true T2WI is noticeable.

(https://files.aievolution.com/prd/asn2101/abstracts/abs_2209/FigureALL_HR.jpg)

Reference One:

Cameron IL, Ord VA, Fullerton GD. Characterization of Proton NMR Relaxation Times in Normal and Pathological Tissues by Correlation with Other Tissue Parameters. Magn Reson Imaging 1984;2:97-106.

Reference Two:

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Reference Three:

Liu S, Mok K, Neelavalli J, Cheng YCN, Tang J, Ye Y, Haacke EM. Improved MR Venography using Quantitative Susceptibility Weighted Imaging. J Magn Reson Imaging 2014;40:698-708.

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