Multiple Contrast Mechanisms in Synthetic Images Calculated From a Single IR TrueFISP Experiment

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Introduction

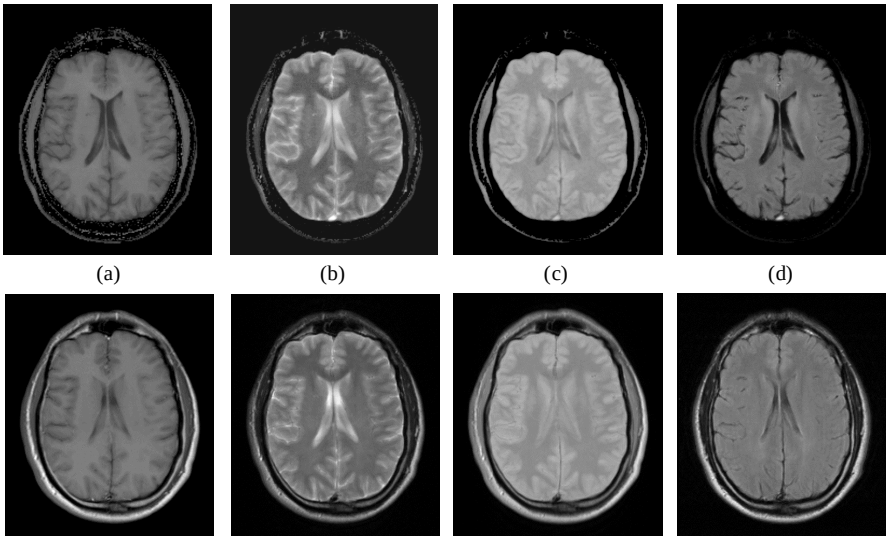
While a major strength of MRI is the wide array of contrast mechanisms available to exploit, it is fair to say that nearly all standard clinical examinations include T_1 and T_2 weighted images, images from fluid attenuated inversion recovery (FLAIR) sequences, and sometimes spin-density contrast as well. Images bearing these various forms of contrast information have to be obtained using separate pulse sequences, posing the dual problem of increased scan time (with consequent patient discomfort, diminished possibility of collecting alternative forms of contrast, increased consumption of scarce scan time, etc.) and also the potential of misregistration of clinically relevant anatomical information between different kinds of images. The latter problem can arise in part due to patient motion between scans, and slightly different slice profiles in the various sequences. Inversion recovery True FISP imaging holds the potential to solve these problems simultaneously. It has been shown that the signal time course sampled with a series of consecutive TrueFISP images after spin inversion may be described by a three-parameter monoexponential fit function. The T_1, T_2, and relative spin-density maps can then be extracted directly from the fit parameters (1,2). Here we propose a method to construct the clinically relevant spin density, T_1, and T_2 weighted images and also images with contrast similar to FLAIR from these maps obtained from a set of images from a single IR-TrueFISP experiment.

Methods

All experiments were performed on a 1.5 T whole body Siemens Vision clinical scanner (Siemens Vision, Erlangen, Germany) equipped with a standard quadrature head coil, on healthy volunteers. Using a segmented IR-TrueFISP imaging sequence, the signal recovery after inversion was sampled with 38 images. Acquisition parameters included TR of 6.46 ms, flip angle of 50°, 21 lines per image segment (136 ms per image), 5 second delay between end of imaging and next inversion, and a total time cost of 2.05 minutes. For comparison, T_1-weighted spin echo images with TR/TE of 500/14 ms, T_2-weighted and spin-density weighted turbo spin-echo with TR/TE of 4000/16 ms and 4000/98 ms, respectively, with a slice thicknes of 8 mm, FOV 256 x 256 mm^2, and a data matrix of 256 x 234-256. FLAIR images were obtained with TR/TI/TE of 6000/2200/105 ms, FOV of 192 x 256 mm^2 and a data matrix of 192 x 256. The in-plane resolution was therefore ~1 x 1 mm^2 for all images. The total imaging time for the comparison data set (T_1, T_2, and spin-density weighted plus FLAIR images) was 11.37 minutes.

Results

From a single IR-TrueFISP data set, the T_1, T_2 and relative spin-density maps were constructed using the formalism presented in (2) based on an analytical approximation provided in (3). Synthetic "T_1-weighted", "T_2 weighted", "spin-density weighted" and "FLAIR" images (CSF-nulled, T_2-weighted) were then extracted from the data set. These calculated images from the IR-TrueFISP data set are shown in Figure 1 (a-d), above their counterparts obtained using separate traditional sequences (e-h).



(a) (b) (c) (d)

(e) (f) (g) (h)

Figure 1: Synthetic (a) T_1-weighted, (b) T_2-weighted, (c) spin-density weighted, and (d) FLAIR contrast images calculated from a single IR True-FISP data set, compared to images with similar contrast information, obtained traditionally as four separate data sets (e-h).

Discussion

The images in Figure 1 show that contrast information required for a standard clinical MRI examination is closely reproduced in the images constructed from only the IR-TrueFISP data set and resultant T_1, T_2, and relative spin density maps. A minor difference between the two sets of images is that venous sinuses in the images from the TrueFISP data are brighter than in the standard images, relating to the inherent flow sensitivity of the sequence. The CSF spaces in the calculated FLAIR images are more prominent than in the obtained image, possibly due to partial volume effects in the calculation of T1 maps. This may well prove to be an advantage during image interpretation. On the other hand, in the spin-density weighted images, the CSF in the ventricles is slightly darker in the calculated images, because the 5 second delay between imaging and next inversion is insufficient to allow complete T_1 relaxation in CSF, resulting in minor errors in the parameter maps. If desired, this minor difference is readily eliminated by slightly increasing the delay between imaging and inversion. Pixel-by-pixel correlation analysis reveals close agreement between the calculated and traditionally acquired images.

The synthetic images highlight the wealth of contrast information that can be derived from the data with significant potential time savings, and also increased scan efficiency because of the quantitative information available from the parameter maps themselves. These reconstructed "standard" images can be provided to the interpreting physician, along with an image where a desired amount of various kinds of contrast can be "dialed in," depending on the likes/dislikes of the individual, and the clinical question at hand. Additionally, since the images are derived from the same data set, they are precisely registered with one another, and thus the physician is not required to mentally perform this important step while interpreting the images. Finally, the underlying quantitative T_1, T_2 and spin density information can be made available to the physician, again making the interpretation step easier.

Acknowledgments

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References

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