

Motion Sensitivity in MR Fingerprinting

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Purpose

MR Fingerprinting (MRF) (1) was recently introduced to provide fast and robust simultaneous estimation of T1, T2, and resonance offset. An interesting feature of MRF is that it was reported to have strong immunity to certain types of motion. The goal of this study is to test various types of motion and its effects on the quality of the output maps using MRF.

Methods

The fingerprinting process was implemented as described in (1). MR Fingerprinting matches the measured signal over time of a pixel to an entry in the dictionary containing possible signal timecourses corresponding to a list of possible T1, T2, and off resonance values. When matched to a particular timecourse, the pixel is assigned the associated T1, T2, and off resonance values, and all three maps can be created after the process is completed for every pixel. The dictionary is composed of every T1, T2, and off resonance values run through a Bloch simulator. To test rotation of the head and its effects on the scan, input images were rotated to a 15-degree angle beginning at various points during the scan. The time of the rotation was varied from 0-100% of the way through the scan. In comparison, in (1) random movements were present for the last 3s of a 15s long scan. The Matlab function `imrotate` was used to simulate the rotation of the head during the scan. To test translation of the head, sub-pixel shifts were simulated using the Fourier shift theorem. It was estimated that the potential translation of the head during a scan was 1cm.

Results

Figures 1 and 2 shows output T1 and T2 maps in the presence of rotations and translations. Figure 3 shows the RMSE for the T1 and T2 maps.

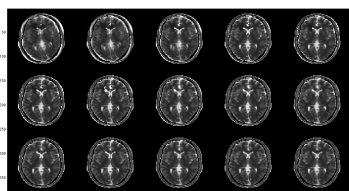
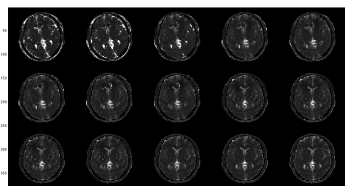


Figure 1: a.) T1 maps rotated at increasingly later times during the scan



b.) T2 maps rotated at increasingly later times during the scan

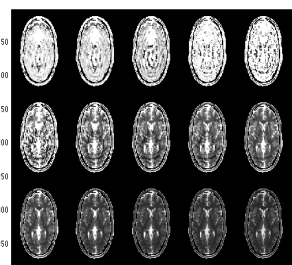
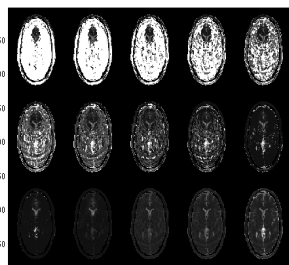


Figure 2: a.) T1 maps translated on the Y-axis at increasingly later times.



b.) T2 maps translated on the Y-axis at increasingly later times.

Discussion:

It was found that T1 maps were much less sensitive than T2 to the rotation and translation. For the T1 maps, as rotation begins to occur later than 25% of the way through the scan, the motion corruption has much less of an impact on the quality of the output maps. We hypothesize that this is because a large amount of T1 related signal change occurs at the beginning due to the initial inversion pulse. This results in a clearly rotated output map for the first image and quickly reorients as less and less of the T1 signal is affected by rotation. As shown in Figure 3a, the RMSE of the output T1 maps becomes markedly lower when the transition occurs at 25% and onwards. T2 maps show a slower recovery of output map quality as shown in Figure 3b. The first few maps are clearly rotated in one position, while the last three are rotated in the other position, and a more symmetrical transition occurs between these extremes. Similar analysis applies to the translation of the head. For translation, there are clear signs of motion corruption in the early T1 maps shown in Figure 2a and likewise, the quality of T2 maps show a more gradual and symmetrical dependence.

References

1. Ma et al, Nature:187:192, 2013
2. Hargreaves B., <http://www-mrsrl.stanford.edu/~brian/vdspiral/>

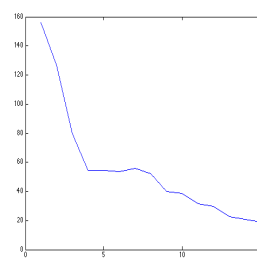
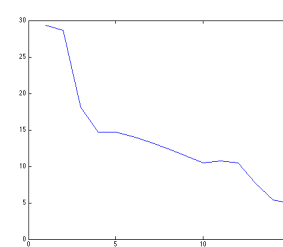


Figure 3: a.) RMSE of the output T1 map compared with the motionless input maps.



b.) RMSE of the output T2 maps compared with the motionless input.