Motion correction in MRI with multi-channel FID navigators

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Introduction

Magnetic resonance imaging (MRI) is a valuable imaging modality to visualize pathologies inside a human body non-invasively. However, MRI is also highly susceptible to subjects' motion. Motion can degrade images and disqualify them from diagnostic purposes. To mitigate this problem we aim at utilizing the latest available multi-coil technology in combination with the free induction decay (FID) navigator technique for motion correction in neurological imaging.

FID-Navigator

A free induction decay is the simplest form of an MR signal and it has been already shown that the FID can reliably be used for motion detection [1,2] (Figure 1). A multi-channel head coil is routinely used in head imaging and provides great potential for motion tracking in all three dimensions. When an FID navigator is acquired with a spatially distributed set of receive arrays, as provided by the head coil, it is possible to deduce the motion parameters from the signal changes. Even though, an FID navigator has the possibility to provide an accurate means for motion characterization, it is still subject to current research to find the underlying correlation between subjects' motion and the FID signal modulation.

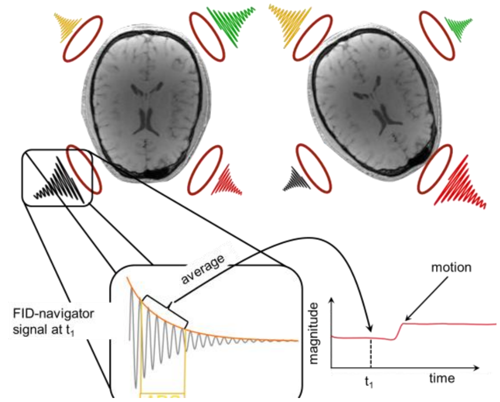
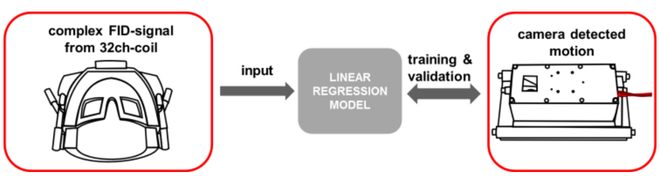


Figure. 1 FID-signal changes in different coil elements due to rigid head motion.

Proof of Concept



$X = (r_1, \dots, r_{32}, \varphi_1, \dots, \varphi_{32})$ $\quad f^* \quad$ $Y = (Y_1, Y_2, \dots, Y_6)$

$$f^* = \beta_0 + \beta_1 r_1 + \dots + \beta_{33}\varphi_1 + \dots + \beta_{64}\varphi_{32}$$

$$f^* := \underset{\beta}{\operatorname{argmin}} \|Y - f(X)\|^2$$

Figure. 2 Schematic overview of the training and validation process to show the relationship between camera detected motion and FID-signal changes.

To show that it will be possible to track motion accurately with a multi-channel FID navigator we conducted an experiment. An FID signal was acquired during a 6 minutes scan of a human volunteer while performing complex head movements. At the same time, the motion was recorded with an optical tracking system [3]. A linear additive model was used to show that a relationship between the FID signal changes and camera detected motion exists (Figure 2). The phase and the magnitude of the FID signals was taken as 64 input variables X to explain each of the six motion parameters Y (rotation and translation in x, y, and z direction). The model f^* was found with a least squares fit. By performing a k-fold cross validation where a subset of the acquired data was used to train the linear model and the remaining set to validate the prediction performance. We could show that the multi-channel FID navigator is able to predict motion with high accuracy [4] (Figure 3).

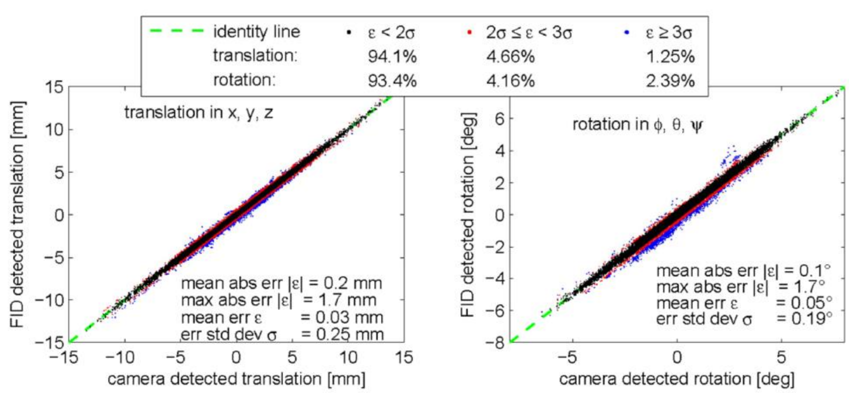


Figure. 3 The crossvalidation shows a good correspondance of FID-predicted and camera detected motion parameters for both, rotational and translational head movements.

References

[1] Kober, T., et al., *MRM*. Head motion detection using FID navigators. (2011), *66*(1), 135–43

[2] Brau, A. C. S., & Brittain, J. H. *MRM*. Generalized self-navigated motion detection technique: Preliminary investigation in abdominal imaging. (2006), *55*(2), 263–70

[3] Maclaren, J., et al., M. *PLOS ONE*. Measurement and Correction of Microscopic Head Motion during Magnetic Resonance Imaging of the Brain. (2012), *7*(11)

[4] Babayeva, M., et al., ISMRM, Can multi-channel FID navigators quantify head motion? (2013), #306

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