Preliminary Study of Resuability of Optimized Trajectory for SENSE

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Introduction: The speed of imaging remains one of the basic challenges in Magnetic Resonance Imaging. Parallel Imaging [1] (PI) has been widely used in fast imaging to attempt to solve the bottleneck problem since 1990s. However, a large amount of work was focused on studying how to reconstruct an image from a fixed undersampling design. Much less work was done on how to choose the sampling design at the first place. To our knowledge, even no paper has been published on studying the reusability of optimized trajectory. Since trajectory optimization is usually computationally expensive, in this work, we focus on studying the reusability of optimized trajectory. This topic was studied from the following 4 aspects: whether the optimized trajectory can be shared among a) images of different contrasts of the same subject b) images of different subjects, c) images of different slices of the same subject, and d) images of different coils.

Method: In this work, we use simulated annealing [2] to find an optimized sampling trajectory. We build a new sampling trajectory by replacing some selected lines with the same number of unselected ones in every step. T, temperature of the simulated annealing stands for the number of lines that are changed each time, which starts at 1. An objective function, is used to determine the quality of this new trajectory. If the quality is better, the trajectory is accepted and the simulated annealing continues. Otherwise, the trajectory is accepted at a certain probability, which is negatively correlated to the qualitative difference of the new trajectory and the former one. For simplicity, root-mean-square-error (RMSE) of the two images is used to define the objective function:

$$\mathrm{error(RMSE)} = \frac{1}{\max(x) - \min(x)} \sqrt{\frac{1}{N} \sum_{i=0}^{N-1} (x(i) - \tilde{x}(i))^2}$$

SENSE [3] was used to reconstruct the image. Brain images of 2 subjects were scanned on a 3T Philips system (Philips, Best, the Netherlands) both T1-weighted (fat suppression, TSE, TR=3000, TE=90) and T2-weighted (fat suppression, SE, TR=400, TE=10), with 8-channel and 32-channel coils (Invivo Corp., Gainesville, U.S.A). Experiments were designed to evaluate the reusability of optimized trajectory from those 4 aspects. The trajectories optimized using T1w image, subject 1, slice 22, and 8-channel coil were applied to T2w image, subject 2, slice 22, and 32-channel coil respectively to test the reusability.

Results: The reconstructed images using equally spaced and optimized sampling trajectories are compared for each case at a reduction factor of 5. The error maps are brightened 10 times. Fig. 1 shows the case we use equally-spaced (2) compared with optimized (4) sampling trajectory. This optimized trajectory is shown in Fig. 6. Figs.2-5 show one example of those 4 questions respectively.

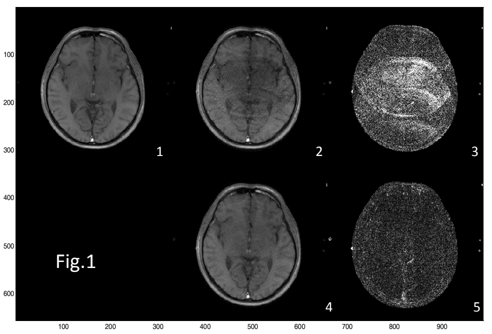

Fig.1

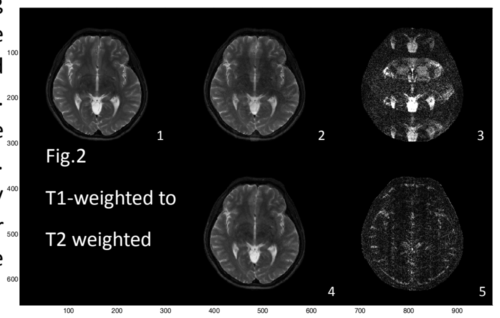

Fig.2 T1-weighted to T2 weighted

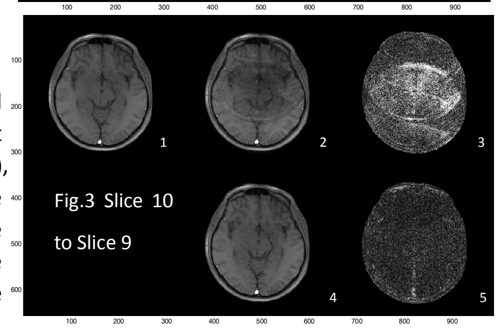

Fig.3 Slice 10 to Slice 9

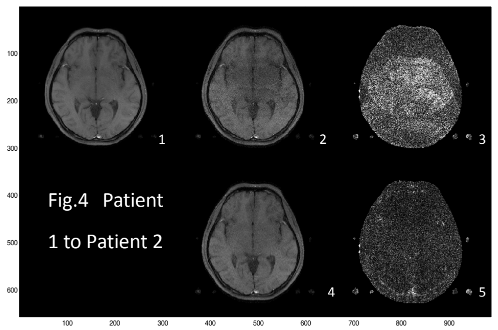

Fig.4 Patient 1 to Patient 2

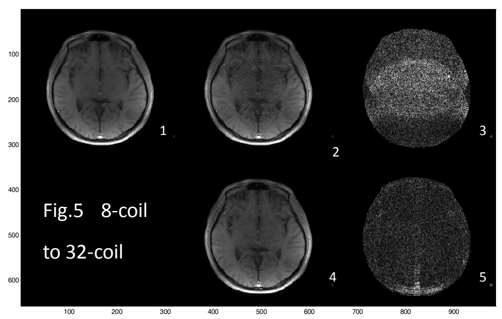

Fig.5 8-coil to 32-coil

Discussion and Conclusion: In all 4 scenarios, images reconstructed using an optimized trajectory have lower RMSE compared with the images reconstructed using an equally-spaced trajectory. This work demonstrates the potential reusability of the optimized trajectory. It is important to adopt trajectory optimization scheme in clinical practice since only limited calculation time is available for trajectory optimization.

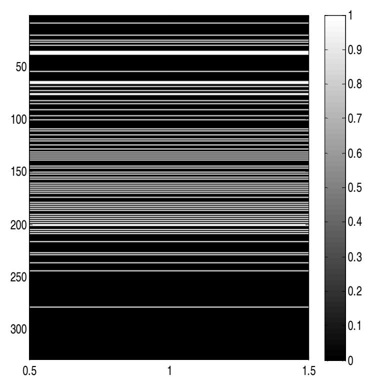

Fig.6

References: [1] Heidemann, R. M. et al. European radiology 13, 2323-2337 (2003). [2] WKirkpatrick, S., Gelatt Jr, C. D. & Vecchi, M. P. science 220, 671-680 (1983). [3] Pruessmann, K. P., Weiger, M., Scheidegger, M. B. & Boesiger, P. Magn Reson Med. 42, 952-962 (1999).