Master's Thesis:
Optimization of Free Non-Cartesian MRI Trajectories under Hardware Imperfections

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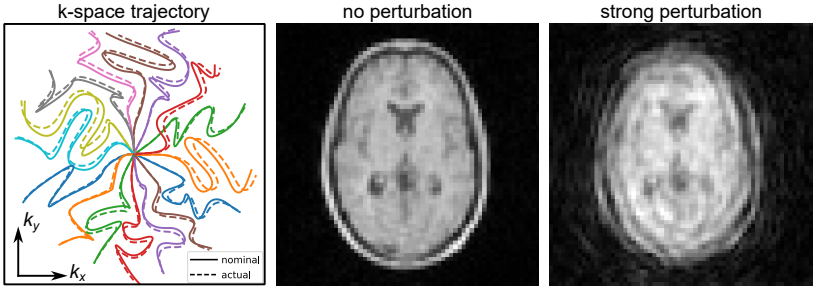
Overview

In MRI, images are formed by sampling data in k-space. Common sampling strategies include Cartesian, radial, or spiral trajectories. More recently, freely optimized non-Cartesian trajectories have emerged [1,2]. These promise improved image quality, faster acquisitions, and more flexible contrast encoding

However, such trajectories are often highly sensitive to hardware imperfections (e.g. gradient delays, eddy currents, system nonlinearities), which can lead to severe image artifacts [3].

Goal:

Develop and evaluate methods to optimize free non-Cartesian MRI trajectories while explicitly accounting for hardware imperfections.
The goal is to make freely optimized trajectories more robust and practically usable on real MRI systems.



Freely optimized k-space trajectory (left) shown under ideal conditions and in the presence of hardware-induced perturbations. The resulting deviations from the nominal trajectory lead to visible image artifacts (right).

Specific tasks

- Get familiar with the MRzero simulation framework [4]
- Perform free trajectory optimization based on numerical simulations
- Integrate existing models of hardware imperfections into the simulation framework
- Validate optimized trajectories experimentally using phantom measurements on the MRI scanner
- Document and illustrate the results

Recommended Knowledge

- Python (NumPy, PyTorch or similar)
- Basic knowledge of MRI sequences and reconstruction
- Interest in numerical optimization / machine learning

Literature

1. Wang et al. *Stochastic optimization of three-dimensional non-Cartesian sampling trajectory.* Magnetic Resonance in Medicine. 2023;90(2):417-431. doi:10.1002/mrm.29645
2. Glang et al. *Advances in MRzero – supervised learning of parallel imaging sequences including joint non-Cartesian trajectory and flip angle optimization.* Proc. Intl. Soc. Mag. Reson. Med. 29 (2021); Program Number 4200. https://cds.ismrm.org/protected/21MProceedings/PDFfiles/4200.html.
3. West et al. *MR sequence design to account for nonideal gradient performance.* Magnetic Resonance in Medicine. 2026;95(2):1135-1145. doi:10.1002/mrm.70093
4. `https://mrsources.github.io/MRzero-Core/`

Contact

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Feel free to get in touch without obligation, and we can discuss the project and see if it's a good fit for you.