

Bachelor's or Master's Thesis:

Derivative-Free Optimization of MRI Sequences

Overview

MRI offers remarkable flexibility: By combining simple sequence building blocks, many different image contrasts can be generated. Recent research treats this **sequence design process as a learning problem** and uses simulations for automated optimization, as in projects like MRzero [1]. Even more experimentally, MR-double-zero [2] optimizes directly on the real MR scanner where no numerical derivatives are available.

Goal: Investigate and compare derivative-free optimization methods, such as **evolution strategies** and **Bayesian optimization**, to evaluate their potential for automated, data-driven MRI sequence optimization in simulations and on the scanner.

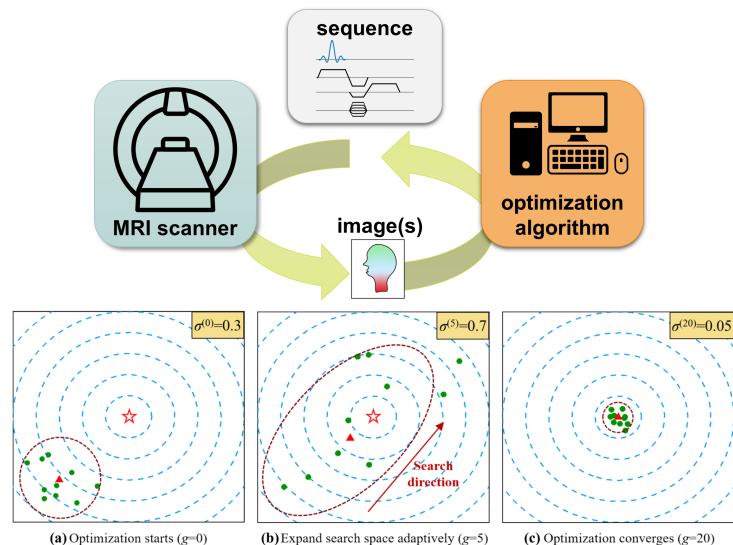


Illustration of "self-learning MRI". Bottom row from
doi:10.1007/s00366-022-01642-5

Specific tasks

Depending on the scope (Bachelor or Master) you will

- do literature review, familiarize with derivative-free optimization
- set up test problems for sequence optimization based on existing MRzero code
- investigate and compare derivative-free optimization algorithms and toolboxes, e.g. [3]
- investigate batched optimization methods
- perform proof-of-concept validation at the MR scanner
- document and illustrate the results

Recommended Knowledge

- Programming in Python
- Basics of MRI
- ideally: basics of machine learning and optimization

Literature

1. Loktyushin et al. *MRzero - Automated discovery of MRI sequences using supervised learning*. Magnetic Resonance in Medicine. 2021;86(2):709-724. doi:10.1002/mrm.28727
2. Glang et al. *MR-double-zero - proof-of-concept for a framework to autonomously discover MRI contrasts*. Journal of Magnetic Resonance. May 2022:107237. doi:10.1016/j.jmr.2022.107237
3. Rapin and Teytaud. *Nevergrad - A gradient-free optimization platform*. <https://github.com/FacebookResearch/Nevergrad>. 2018.

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.