Master Thesis:

Optimization, Statistics, and System Theory for Improved MR Fingerprinting

Philips Research OVGU

Starting date: May 2021

Wanted: A highly motivated Masters' student of mathematics or statistics that feels comfortable with the problem below and that, at best, has good command of a programming language.

MR Fingerprinting is a new, quantitative imaging technique in Magnetic Resonance Imaging (MRI). In short, MR Fingerprinting relies on the simulation of the Bloch equation, a parameter-dependent ODE for the magnetization M of the form $\dot{M}(t) = f(M(t), B(t), T_1, T_2)$, where the magnetic field B is determined by the parameters of the acquisition. Varying relaxation times T_1 and T_2 yields a series of trajectories forming a so-called dictionary. Fingerprinting means the matching of the acquired under-sampled data with the dictionary entries for querying the relevant tissue-specific parameters called 'Maps' in Figure 1 G).

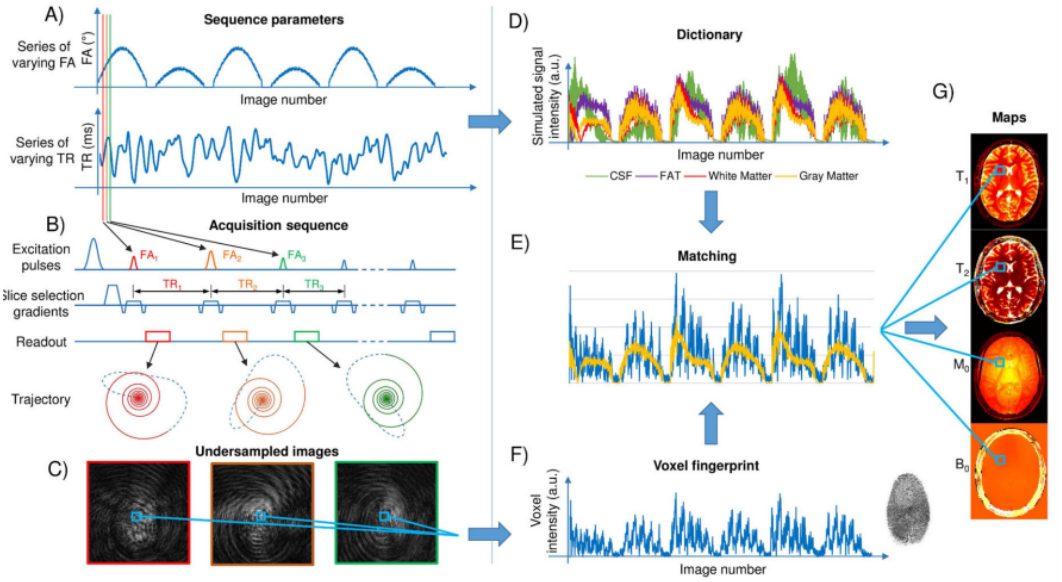

Figure 1: Overview MR Fingerprinting taken from [2].

The development and implementation opens a number of options for a Master's project:

- **System Theory:** Re-formulation of the MRF dictionary computation as an input-state-output system and model order reduction of the underlying Bloch equation. While the reformulation enables the matching by established system identification routines, a reduced order model can be used for a-posteriori checks of the selected parameters or for enriching the dictionary in the relevant parameter range.
- **Statistics:** The estimation of parameters based on data is a common task in statistics. Apart from implementing and testing relevant routines for Fingerprinting, the inclusion of tailored statistical approaches for the particular problem of Fingerprinting can be useful for improving the dictionary in general and for providing confidence estimates for the selection obtained from classical matching.
- **Optimization:** Fingerprinting seeks for the best match of collected data with the precomputed dictionary entries. Tools from mathematical optimization will be used to improve the reliability of the selected optimum and to enhance both the data aquisition and the dictionary through optimal design.

Certainly, all aspects can be combined and adjusted to the personal skills and interests in the final project.

What can you expect?

- A 6 months Master's project on a modern, relevant, and interesting application
- at Philips Hamburg (or remotely for the start)
- with supervision by JProf. Dr. Jan Heiland (`jan.heiland@ovgu.de`) and Dr. Manuel Baumann (Philips Research, `manuel.baumann@philips.com`)
- and a monetary compensation for your living costs.

Please contact the supervisors for details.

How to apply

Please send your application in German or English and include a short CV and transcript of records to the contact by April, 30th.

We are committed to increasing the number of individuals of underrepresented social strata in our field. We hope for many such applications and we will handle these with particular attentiveness.

More and basic reading

[1] Ma, D., Gulani, V., Seiberlich, N., Liu, K., Sunshine, J. L., Duerk, J. L., and Griswold, M. A. (2013). *Magnetic resonance fingerprinting.* Nature, 495(7440), 187–192.

[2] Panda, A., Mehta, B. B., Coppo, S., Jiang, Y., Ma, D., Seiberlich, N., Griswold, M. A., and Gulani, V. (2017). *Magnetic Resonance Fingerprinting - An Overview.* Current opinion in biomedical engineering, 3, 56–66.

[3] Roeloffs V., Uecker M., and Frahm J. (2020). *Joint T1 and T2 Mapping With Tiny Dictionaries and Subspace-Constrained Reconstruction.* IEEE Trans Med Imaging, 39(4):1008-1014.