Extraction of Quantitative Relaxation and Diffusion Metrics from balanced Steady-State Free Precession Magnetic Resonance Imaging

Thesis submitted in partial fulfilment of the requirements for the degree

Master of Science

Graduate School of Neuroscience
Faculty of Science
Faculty of Medicine
University of Tübingen

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Disclosures

- I affirm that I have written the dissertation myself and have not used any sources and aids other than those indicated.
- I affirm that I have not included data generated in one of my laboratory rotations and already presented in the respective laboratory report.

Tübingen, March 2024 _____

Abstract:

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Contents

1. Introduction

- Largest multi modal data set of its kind
- bSSFP now feasible with new HW
- Speeds up scanning times potentially yielding multiple modalities with one scan
- Limited data available for ML applications

Effizient wegen pulsing
Gut für 3D, isotrope auflösung <-> diffusion
Höchste SNR von allen steady state sequenzen
geeignet fuer high field, keine distortion
EPI DWI

Flo's paper & Master arbeit

Rahels Presentation

Pictorial description Klaus review

Oliver bieri fundamentials of bssfp

2. Related Work

2.1. Brain Imaging DataStructure

what why what it looks like

2.2. MRI Processing/Registration Tools

FSL, SPM, ANTS, FreeSurfer

2.3. Quantitative MRI using bSSFP

Some bla bla about qMRI development in the past.
In depth description of sequence, profile, banding

2.3.1. Configuration Modes & Asymmetry Maps

karla miller paper

2.3.2. T1 and T2 Map Estimation using MIRACLE

TESS & MIRACLE papers

2.4. Deep Learning in Medical Imaging and MRI

UNet, challenges, impact of transformers, ...

3. Methods

3.1. The Dove Dataset

Some stats on size

3.1.1. Participants & Study Design

briefly describe participants, task, scanning times (of the day)

3.1.2. Recorded Sequences

cf gais doc. Details on acquisitions

3.2. Processing Pipeline

requirements

3.2.1. bSSFP

3.2.2. Phase Correction

Why, how

FSL Pipline als füller wenn nicht genug content. Kurz auf jeden Fall beschreiben

3.2.2.1. Motion Correction & Co-Registration

Initial FSL Pipeline motion correction to first. Direct, inverse to t1w, B1, T1w rescaling. Difficulties with artefacts, special requirements due to quanti, auto scaling of registered image

SPM Pipeline exact steps that spm executes. difficulties with docs, lack of API

Weniger robust als spm, nicht zu sehr ins detail

Nicht stabil genug => SPM

3.2.3. DWI

TODO ask svenja what was done

3.3. Machine Learning-based DWI Tensor estimation from bSSFP data

MONAI, torchio, pytorch lightning.

3.3.1. Baseline

UNet + some extra layers to fit output dim.

3.3.2. Augmentation

3.3.3. PreTraining

Sparse data, small batch sizes. => Augmentation not enough => Pre training

AutoEncoder PreTraining As auto encoder. train autoenc for bssfp only

ExtraHead Transfer and Fine tuning freeze autoenc, add head. transfer then unfreeze all and fine tune Unet + extra head

3.3.4. Complex vs. non-complex

input and weights

TemporalConv1D vs. nicht

Am anfang prozessierte daten zeigen

4. Results

4.1. Baseline

4.2. Augmentation

4.3. Pretrained

4.4. Complex vs. 2-Channel

5. Discussion

5.1. Limitations

Not patch based but whole image
New stuff not tried
not ultra high res => learns blur distribution

5.2. Future Work

5.2.1. Modular Deep Learning

Pretrain autoenc for both.
Use enc of bssfp (or conv transf. for enc) and dec of DWI/specialized for modality
LDM for latent translation

5.2.2. Conv Transf.

New kid on the block

5.2.3. Neural Arch Search

DiNTS

6. Acknowledgements

Rahel, Flo, Klaus

Appendix

Figure .1. ***A. & B.*** *SNc and projections to the dorsal striatum in healthy subjects and patients with PD. In the healthy subject, the SNc is still highly pigmented due to the melanin-containing dopamine-producing cells being intact. The SNc projects to the striatum and delivers normal amounts of DA into the basal ganglia (BG) circuit. If the dopamine-producing neurons undergo apoptosis, the pigmentation decreases and so does the amount of dopamine adimnistered to the striatum.* ***C.*** *Photomicrographs of Lewy bodies.*

A. Discussion