**Introduction**

Parkinson’s Disease

MRI biomarker T2\* (papers show T2\* is good biomarker)

Ways to obtain T2\* value (paper of the gold standard method)

The new method (quadratic RF spoiling bSSFP) is faster and more robust to movement.

The current problem:

Different TR will have different performances 🡪 Literature needed and explained briefly

Different T2\* will have different accuracy 🡪 literature needed and explained briefly

Do not have an optimised sequence for it, quite new technology.

Not enough trials with real data. 🡪 current trials use long TR and lots of periods.

Need simulation to estimate the performance.

Aim for this project:

1. Model the spin’s performance under the novel quadratic RF spoiling SSFP sequence based on Bloch Simulation.
2. Analyse the accuracy of acquiring T2\* from F-states exponential decay while using different periods and different TR quadratic RF spoiling SSFP sequences with the Bloch Simulation model.
3. Further analyse the T2\* acquiring accuracy when noise is included to model and predict the method’s efficiency in reality. Then choose coefficients that will give acceptable results according to the analysis to acquire MRI data.
4. Acquiring MRI data from a standard phantom using quadratic RF spoiling SSFP with selected period and TRs and calculating T2\* using the novel method.
5. Acquiring MRI data from a standard phantom using gold-standard multi-echo gradient echo sequence (multi-echo FLASH) and calculating the ground truth T2\* value.
6. Compare and analyse the T2\* obtained using the novel method and the ground truth to verify the accuracy of the new method.
7. Compare the T2\* calculation in reality with the prediction of the model to evaluate and improve the model.

The newly proposed kaSPGR pulse sequence is theoretically shown that when applying an N-periodic quadratic RF spoiling SSFP sequence, the T2\* value can be acquired by fitting the exponential decay in the F-state (Fourier domain of off-resonance profile). Pete et al have acquired a quantitative R2\* image of the brain using the newly proposed method and a Gold-standard R2\* map is also provided for comparison. However, no numerical analysis and proof of the kaSPGR T2\* mapping accuracy has been performed in the previous study. In this project, the performance of the kaSPGR T2\* measurement accuracy is first analysed using computer simulation, and then using the MRI data acquired from a phantom.

**Methods**

a Bloch Simulation model of the kaSPGR sequence is constructed using Python, which is used to study the behaviour of spins and analyse the T2\* measurement accuracy while the kaSPGR sequence with different period and TR values is applied. Suitable coefficients are chosen based on the simulation result and used to acquire MRI data from a standard phantom.

Therefore, a numerical analysis of the method is desired to be performed in order to prove the accuracy of the kaSPGR calculated T2\*.

Simulation

Constructing a model to predict the pulse sequence performance is essential in the first place as it aids understand the complex behaviours of the spins and provides a tool to test different circumstances without carrying out a real MRI scan, which is really costly. The model is built based on the well know Bloch Equation

We are able to use the Bloch simulation model for the performance of spins of different off-resonance frequencies.

Used Bloch simulation to generate the off-resonance profile.

1. Add field inhomogeneous

(model what’s happening in reality, not single off-resonance spin in each pixel, gonna have other components, which is a L)

Fourier transform to get the F-states (according to xxx paper, the F-states of Bloch simulation only contain T2)

We want T2\*, which is a field inhomogeneous bias based on T2. Use the T2 value for Parkinson’s substantia nigra.

The equation used. T2’ T2\* T2

Get the range of T2’ we used 🡪 convolve = multiply in the F domain

1. Add noise

Monti Carlo simulation

Random noise is added to the off-resonance profile of the previously obtained off-resonance profile with field inhomogeneous 1000 times to acquire 1000 measured data.

(example figure shows the same off-resonance profile with different random noise added)

Simulation data acquisition complete. The next step is to use the simulated data to calculate the measured T2\* value.

1. Perform exponential fit

F-state of the simulated off-resonance profile, fit an exponential line to get the T2\* value (supported by xxx paper)

Compare ground truth T2\* and measured T2\*

Obtain bias, standard deviation calculation.

Obtain maps

Phantom scan

MRI scan using phantom (SN:130-102) is performed under

**Results**

Simulation Result

Optimal TR value is around 6 ms

Phantom Result

**Pixel by pixel T2\* comparison**

The measured T2\* plot against ground truth shows a generally acceptable alignment with the simulation result. Perform extremely well at small T2\*.

**Percentage error comparison**

Percentage error generally within the range of +-10%

**Effective SNR comparison**

At a similar flip angle, which means a similar amount of excitation energy, the signal-to-noise ratio of the new method is generally larger than the gold standard method. Extremely well at lower T2\* magnitude.

At small T2\*, the decay is very fast, which means the signal physically exists and is able to be detected is limited. While the new method uses the signal from N scans to construct one F-state point, by summing up the signals, the noise is reduced largely, therefore the T2\* SNR is improved compared with the gold standard.

However, using a more optimised 90 flip angle, (as a larger amount of excitation energy input).

**Discussion**

Result suggests:

What simulation result suggests

Is it aligned with real data for phantom

Is it aligned with real data from in vivo scan

Limitations:

Simulation limitations

* Simulation’s alignment with reality. Way to model inhomogeneous map

**Conclusion**

This project provides a simulation model for quadratic RF spoiling bSSFP sequence, which can be used to estimate the best scanning parameter according to the circumstance. The experiment has show the alignment of the model with reality…

**References**