INTRODUCTION

What is the problem?

* Parkinson’s disease is irreversible, therefore early diagnosis is important.
* Iron overloaded in the substantia nigra region in the brain is an early sign of Parkinson’s disease and can be detected using MRI.
* MRI signal decay exponentially against time with a time constant T2\*, which is tissue and magnetic field inhomogeneity dependent. The iron overloaded at SN will distort the magnetic field and cause a change in T2\* at that region, therefore can be used as an effective biomarker for Parkinson’s disease diagnosis.

Why is this interesting?

What are previous solutions?

* T2\* acquiring (traditional way)
* T2\* map to visualize, map T2\* on top of a reference image
* The reference image is normally obtained by averaging the image used for T2\* calculation, however as the T2\* is short and the signal decay rapidly, the reference image constructed this way has low SNR efficiency and does not have good contrast.
* The alternative way is using other MRI techniques with more effective SNR and contrast to perform a separate scan and generate the reference image, but as they are separate scans, registration is needed when mapping the T2\* value on the reference image.
* The images for the T2\* calculation
* The traditional way of calculating the T2\* value is based on acquiring MR images at different time delays. Using these images, the T2\* time constant of the tissue in each voxel can be calculated by fitting the signal’s exponential decay in that voxel. The T2\* of the region of interest will then be colour-coded and mapped on top of a reference MR image, this MR imaging technique is called T2\* mapping.
* And a reference MRI image is generated by either averaging the acquired images used for T2\* calculation or performing an extra scan.
* However, the T2\* of the SN region is short and the signal decay rapidly, which makes the reference MR image has bad contrast and low SNR efficiency.

What's the new solution? And when/why is it better than the old ones?

* The new T2\* mapping method is based on an MRI technique which generates images with better contrast and SNR efficiency called N-periodic RF spoiling steady-state free precession (SSFP).
* N images will be acquired using the new method, each containing information coming from different times of the T2\* decay. By extracting useful information from each image, the T2\* decay signal can be reconstructed and T2\* can be extracted by fitting the decay.
* Not simply time decay relationship between images
* They acquire using same TE, but different phase shifts each time, RF spoiling
* Each contain information for different time, need to be reconstruct to see the signal decay due to T2\*
* The new solution uses an N-periodic RF-spoiling SSFP sequence, which produces N images each containing information coming from different times of the T2\* decay. By extracting useful information from each image, the T2\* decay signal can be reconstructed and T2\* can be extracted by fitting the decay.
* **Advantages- contrast, SSFP contrast, higher SNR efficiency in the real image**

Give a basic preview of the rest of the paper

* Analysis of the T2\* acquisition accuracy of the new method using model simulation, followed by analysis using MRI data acquired from a phantom, which both show the new method is able to acquire acceptably accurate T2\*.
* Evaluation of the effective T2\* SNR compared with the current gold-standard method, also align.
* **Advantage: observed**
* ~~The new method can theoretically increase the speed of acquisition, improve the SNR and be more robust to motion.~~

INTRODUCTION #v1

What is the problem? / Why is this interesting?

* Parkinson’s disease is irreversible, and early diagnosis is important.
* The tissue’s MRI property T2\* time constant is an effective biomarker for Parkinson’s disease early diagnosis.

MRI signal decay exponentially against time with the time constant T2\*, which is tissue and magnetic field inhomogeneity dependent. One of the early signs of Parkinson’s disease is iron overloaded at the substantia nigra region, the overloaded iron will distort the magnetic field and cause a change in T2\* at that region, therefore can be used as an effective biomarker for Parkinson’s disease diagnosis.

What are previous solutions?

* Acquire images at different times and use the signal’s exponential decay in each voxel to get the T2\*.
* The T2\* value calculated is mapped on top of a reference image to generate a T2\* mapping image.
* Reference images have bad contrast and low SNR as the signal decay rapidly.
* An alternative way is using a separate scan to generate a good-quality reference image, but registration is needed as the T2\* and reference images are separate.

What's the new solution? And when/why is it better than the old ones?

* The new method is able to calculate T2\* using the images acquired with a novel MRI technique which generates high SNR efficiency and good contrast images, called N-Periodic RF spoiling SSFP. By using this technique, a high-quality reference image can be guaranteed.
* For this new method, the images acquire are not simply time decay relationships, they each contain information coming from different times of the T2\* decay. By extracting useful information from each image, the T2\* decay signal can be reconstructed and T2\* can be extracted by fitting the decay same way as the traditional technique.
* It allows for generating a high-quality T2\* mapping image with no extra scans or registration.

Give a basic preview of the rest of the paper

* Analysis of the T2\* accuracy of the new method uses model simulation and finds the optimal scan parameter to be used in an MRI scan.
* Analysis MRI data acquired from a phantom uses the new method and gold-standard method, which shows the new method is able to acquire acceptably accurate T2\*.
* Evaluation of the effective T2\* SNR compared with the current gold-standard method, shows a aligned effective T2\* SNR.
* **Advantage: observed**

INTRODUCTION #v2

What is the problem?

* Parkinson’s disease is irreversible, and early diagnosis is important.
* The tissue’s MRI property T2\* time constant is an effective biomarker for Parkinson’s disease early diagnosis.

MRI signal decay exponentially against time with the time constant T2\*, which is tissue and magnetic field inhomogeneity dependent. One of the early signs of Parkinson’s disease is iron overloaded at the substantia nigra region, the overloaded iron will distort the magnetic field and cause a change in T2\* at that region, therefore can be used as an effective biomarker for Parkinson’s disease diagnosis.

* So, it is very valuable to get the quantitative T2\* image of the brain, and a traditional way is to acquire images at different times and use the signal’s exponential decay in each voxel to get the T2\*.
* However, the motion of the brain makes acquiring MRI images very difficult, and a large amount of data can’t be used because of motion artefacts.
* And it is even more difficult to get a T2\* image of the brain because multiple images are required to obtain one T2\* image.

What are previous solutions?

* Taking several images and averaging them to reduce motion artefacts, but it will make the acquisition time long.
* Using a larger voxel size, so the movement will not have a huge impact, but it worse the resolution, and not able to see small tissue structures in the brain.

Why is this interesting?

* Desirable to find a method robust to motion in the brain, not sacrifice resolution or scan time, and able to accurately measure T2\*.

What's the new solution? And when/why is it better than the old ones?

* A new T2\* imaging technique is suggested, which can reduce the effect of motion while maintaining short acquisition time and good resolution, the technique is called k-space-aliased SPGR.
* The images acquired using the new technique are not simply related by decay time, they each contain information coming from different times of the T2\* decay. By extracting useful information from each image, the T2\* decay signal can be reconstructed and T2\* can then be calculated the same way as the traditional technique.
* Theoretically, even if the movement of the brain creates artefacts in some acquisition, it will not have a huge impact on the reconstructed T2\* decay signal, as the signal is obtained by averaging across multiple acquisitions.
* However, there was no quantitative analysis of the new technique’s T2\* accuracy, and no suggested optimal MRI scan parameters for the new technique. It is important to evaluate the new method’s T2\* accuracy and optimal parameters before analyzing the in vivo motion robustness of the new method.

Give a basic preview of the rest of the paper

* Analysis of the T2\* accuracy of the new method uses model simulation and finds the optimal scan parameters to be used in the MRI scan.
* Analysis MRI data acquired from a phantom uses the new method with optimal parameters and gold-standard method, which shows the new method is able to acquire acceptably accurate T2\*.
* Evaluation of the effective T2\* SNR compared with the current gold-standard method, shows a aligned effective T2\* SNR.
* **Advantage: observed**

**Method**

* Knowing the F-states of the signal under this pulse sequence can be used to fit exponential decay and obtain T2\* 🡪 analytical solution
* Find out how different TR and period selections may affect the T2\* calculation.

(Different periods and different TR allow us to acquire different points on the exponential fit, and also there is noise, so there will be optimal TR and period for T2\* calculation)

* Model performance of spins with different T2\* under different N-Periodic RF spoiling SSFP pulse, different TR, different period.
* See the accuracy of the T2\* fit.
* Find the TR and Period can generate smallest bias within MRI machine limit, 6ms TR.
* By extracting useful information from each image, the signal used to fit T2\* decay can be reconstructed and T2\* fit can be performed.
* allows acquiring data lines for multiple images in one shot which is fast, but SNR can be further improved.
* New method has similar advantages as gold-standard Multi-echo GRE, due to adjacent signal acquisition for multiple images.
* At the same time the signal used to fit the exponential curve in the new method is obtained by summing up information from multiple acquired signals, which gives better effective SNR.
* Most straight forward technique is using multiple gradient echo T2\* mapping acquires images separately, so will be largely affected by the motion of the subject.

The signal used to fit the exponential curve is obtained by summing up selected information from multiple acquired signals, which results in better SNR.

The signal used to fit the exponential curve reconstructed from modulate and adds up of multiple acquired signals, which results in better SNR.

* Iron overload at certain areas in the brain is an effective biomarker for early diagnosis of Parkinson’s Disease.
* Iron overloaded can be detected by T2\*, MRI time
* T2\* can be acquired by fitting the exponential decay of the T2\* weighted MR signal when certain pulse sequences are used.
* Current gold-standard method for T2\* mapping use multi-echo GRE sequence. It acquires signals for T2\* weighted images at different times in one repetition and uses the images’ pixel values to fit the exponential curve and get a quantitative T2\* image.
* Current gold-standard method for T2\* mapping fitting the exponential decay pixel-wise using images acquired at different times.
* Current gold-standard method acquire MRI images at different time delay and extract the T2\* time constant from the exponentially decayed signal in each voxel.

This project:

* Analysis of the T2\* acquisition accuracy of the new method using model simulation, followed by analysis using MRI data acquired from a phantom, which both show the new method is able to acquire acceptably accurate T2\*.
* Evaluation of the effective T2\* SNR compared with the current gold-standard method.
* The images acquired using the new technique each contain information coming from different times of the T2\* decay, so the images do not have the straightforward time decay relationship like the traditional method. Instead, the T2\* decayed signal at different times ~~used to fit the exponential decay~~ is reconstructed by summing up the relevant signal extracted from each acquired image.