Master's internship

Metabolic Image Reconstruction Strategy for Fast Acquisition of Magnetic Resonance Spectroscopic Imaging

1 Scientific Context

Magnetic resonance spectroscopic imaging makes it possible to measure spatially distributed NMR spectra, each composed of the spectral signatures of metabolites present in tissues. Applied to the phosphorus nucleus, this is a non-invasive way to monitor energy metabolism and dynamic metabolite concentrations during or after exercise, and thus obtain differentiated information for each individual muscle.

However, the very long acquisition time required to obtain these data with conventional techniques limits its dynamic temporal resolution, and therefore its interest in the context of exercise monitoring.

Previous work [2, 3] enabled to reduce the acquisition time required, based on a priori knowledge of the spectral support of metabolites.

2 Objectives of the internship

The aim of this internship is to continue the work of Jabrane Karkouri's thesis [2], particularly the signal processing part, which had been developed in Matlab.

Firstly, a Python version has been written, but differences are visible in the reconstructions, linked to the non-uniform 2D Fourier transform implementation used, [1] or [4].

Secondly, the used strategy partitions the k-space into assumed instantaneous spirals. The influence of this assumption has not been studied.

Finally, this work was limited to the spectral reconstruction from voxels, whereas the aim is to characterize the different metabolites, i.e. to determine the parameters of a physical model associated with these spectra.

The work will require several steps:

- Familiarize yourself with the existing algorithm on simulated data
- Compare the implementations Matlab aml Python
- Implement a "point" partition acquisition instead of the spiral
- Integrate the physical model in the reconstruction

3 Required skills

- Good Python programming skills (NumPy, SciPy), optionnaly Matlab
- Good knowledge in signal processing
- Interest in biomedical imaging in general, MRI in particular

4 Informations

- Duration of the internship: 5 to 6 months
- Location: Creatis laboratory, 21 Avenue Jean Capelle, Villeurbanne
- Supervisors: Hélène Ratiney (helene.ratiney@creatis.insa-lyon.fr) and Fabien Millioz (fabien.millioz@creatis.insa-lyon.fr)
- Send CV, cover letter and last transcript of marks

References

[1] J. Fessler and B. Sutton. Nonuniform fast fourier transforms using min-max interpolation. *IEEE Transactions on Signal Processing*, 51(2):560–574, 2003.

[2] J. Karkouri. *Exploiting sparse spectrum to accelerate spiral magnetic resonance spectroscopic imaging : method, simulation and applications to the functional exploration of skeletal muscle*. Theses, Université de Lyon, Dec. 2019.

[3] J. Karkouri, H. Ratiney, M. Viallon, R. Prost, and F. Millioz. Time Undersampled Acquisition for Multidimensional Sparse Signals With Application to Magnetic Resonance Spectroscopic Imaging. *IEEE Transactions on Signal Processing*, 69:5289–5298, 2021.

[4] Lin. Python non-uniform fast fourier transform (pynufft): An accelerated non-cartesian mri package on a heterogeneous platform (cpu/gpu). Mar 2018.