The benefit of the MTSat MRI sequence for characterising lesions in multiple sclerosis

Duration: 5 to 6 month, starting in early 2023

Salary: financial support following french regulations + financial help for lunches (cost of a full meal ~2€50)

Location: Empenn team (Inria/IRISA, UMR CNRS 6074), located at IRISA, Campus de Beaulieu, Rennes (France)

Supervisors:
- Benoit Combès (benoit.combes@inria.fr)
- Malo Gaubert (malo.gaubert@irisa.fr)

Keywords: Medical imaging, MRI, image processing, data analysis

Background and motivation: Magnetic resonance imaging (MRI) is now an essential tool for diagnosing various pathologies such as multiple sclerosis (MS). This autoimmune disease is characterised by the formation of lesions visible on MRI in the brain and spinal cord. These lesions correspond in particular to localised destruction of the myelin, a sheath surrounding the axons (connections between neurons) and enabling the more or less rapid conduction of electrical messages between neurons.

In this context, the Empenn team has set up various research protocols to understand the impact of lesions on patients' motor functions. These protocols include MRI acquisitions of the brain and spinal cord. In particular, so-called ‘magnetisation transfer’ images are acquired. The aim of this type of image is to quantify the degree of demyelination (reduction of myelin) of lesions (Figure 1) in the brain and spinal cord of MS patients by calculating a magnetization transfer ratio (MTR). Our group has already published several articles [1,2 3] using this MTR sequence to better characterise tissue damage in people living with MS.

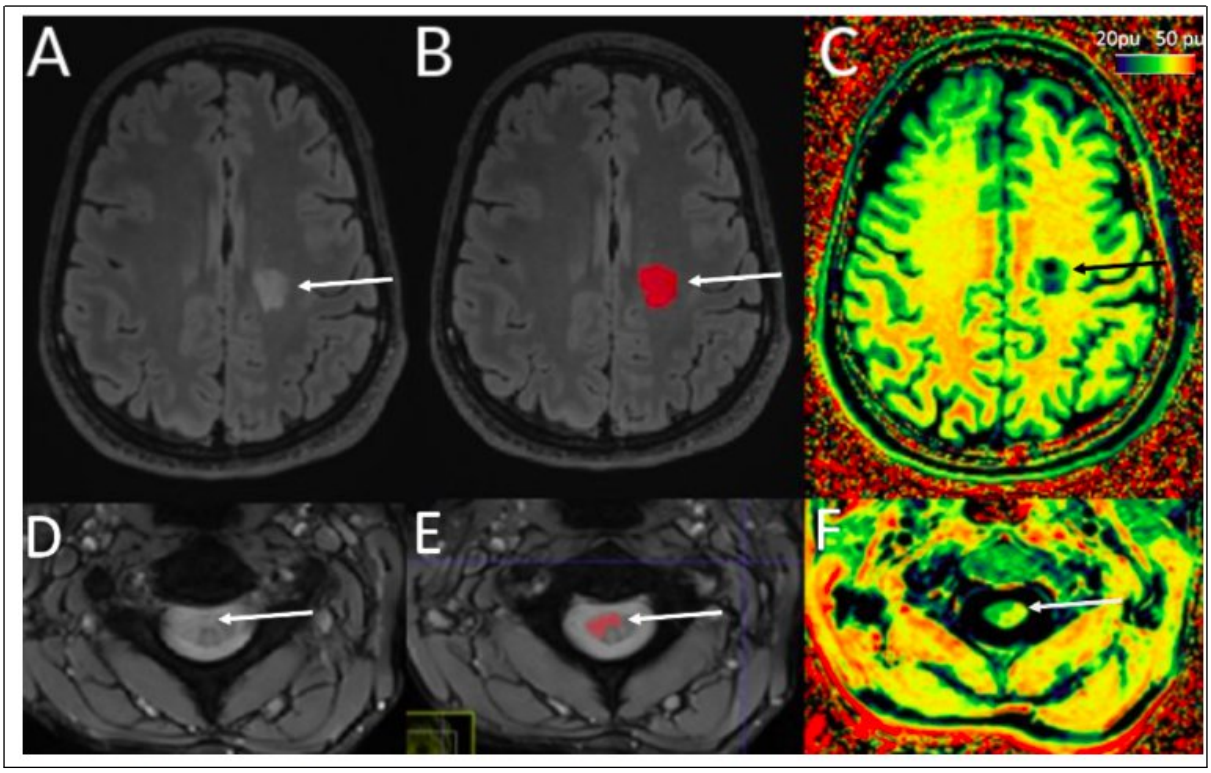

Figure 1*: Example of an MS lesion in a patient's brain (1st row) and spinal cord. Column 1: axial section of an anatomical sequence (FLAIR for the brain, T2*w for the spinal cord). Column 2: same as Column 1 with the lesion outlined in red. Column 3: associated MTR mapping. The warmer (resp. colder) the colours, the higher (resp. lower) the MTR value. Extract from Alice Dufey's medical thesis based on work carried out within the Empenn team.*

Nevertheless, this MTR imaging has major limitations linked to an undesirable dependence of the signals acquired on the T1 of the tissues imaged and to the inhomogeneity of the applied flip angles. These limitations have an impact on the interpretability of the values extracted from these magnetisation transfer images. Interestingly, another model exists that allows T1-weighted acquisition and B1 field acquisition to be added to MTR acquisitions. This model can be used to calculate saturation maps of magnetisation transfer, called MTSat, which are potentially more informative than MTR maps [4]. In our latest imaging studies, T1-weighted and B1-field images were acquired in addition to the standard acquisitions used for MTR mapping. However, the value of these additional acquisitions for our MS imaging studies has not yet been investigated.

Project: The aim of this internship is to evaluate MTsat data in order to quantify the improvements made by this imaging with regard to MTR.

There will be several stages in the course of the internship:

1. Familiarisation with the data and processing tools. Review of the literature on models and studies linking MTR and MTSat.
2. Pre-processing of MTR and MTSat images of the brain and spinal cord in relation to the results of stage 1.
3. Analyses of the variability and reproducibility of the MTSat and comparison of the extracted values with those of the MTR, particularly in people living with MS.

The student will use medical image processing and statistical tools developed within Empenn (Anima, MedInria) or by other laboratories (FSL or SCT for the spinal cord). Depending on the student's knowledge and desire, additional tools may be developed to facilitate processing (automation) and additional analyses (inter-machine comparisons) may be carried out.

Prerequisites:
- Fundamental principles of MRI, Medical image processing, Data analysis.
- Scientific curiosity, rigour and organisation.
- Although not essential, knowledge of scientific programming and basic statistics would be a plus.

How to apply?
Send your CV and cover letter to the two contacts above

References
[1] Combès B, Kerbrat A, Ferré JC, et al. Focal and diffuse cervical spinal cord damage in patients with early relapsing–remitting MS: a multicentre magnetisation transfer ratio study. Mult Scler 2018; 1352458518781999.
[2] Combès B, Monteau L, Bannier E, et al. Measurement of magnetization transfer ratio (MTR) from cervical spinal cord: multi-center reproducibility and variability. JMagn Reson Imaging. 2019;49:1777-1785.
[3] Gaubert M, Bannier E, Chouteau R, Callot C, Ferré J-C , Hamon G, Kerbrat A , Combès B. Magnetization transfer imaging of the whole spinal cord in multiple sclerosis patients. ECTRIMS 2022 - 38th Congress of the European Committee for Treatment and Research in Multiple Sclerosis, Oct 2022, Amsterdam, Netherlands. pp.1-1. ⟨hal-03798043⟩.
[4] Helms G, Dathe H, Kallenberg K, Dechent P. High-resolution maps of magnetization transfer with inherent correction for RF inhomogeneity and T1 relaxation obtained from 3D FLASH MRI. Magn Reson Med. 2008 Dec;60(6):1396-407. doi: 10.1002/mrm.21732. Erratum in: Magn Reson Med. 2010 Dec;64(6):1856. PMID: 19025906.