Offer #2024-08034

Doctorant F/H Measuring brain microstructure through myelin content modelling in neurodegenerative diseases

The offer description below is in French

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

Level of experience : Up to 3 years

About the research centre or Inria department

Le centre Inria de l'Université de Rennes est l'un des neuf centres d'Inria et compte plus d'une trentaine d'équipes de recherche. Le centre Inria est un acteur majeur et reconnu dans le domaine des sciences numériques. Il est au cœur d'un riche écosystème de R&D et d'innovation : PME fortement innovantes, grands groupes industriels, pôles de compétitivité, acteurs de la recherche et de l'enseignement supérieur, laboratoires d'excellence, institut de recherche technologique.

Context

In the context of neurodegenerative disorders, the myelin sheaths surrounding the axons are affected by physiopathological processes. Several techniques have been proposed to measure myelin content with MR imaging relying on different acquisition techniques on the one hand and quantitation techniques on the other hand. One popular acquisition technique is T2 relaxometry [1] but T2* relaxometry (GRASE) [2] is also an interesting surrogate. Other acquisition techniques are proposed such as in (ihMT), which focuses on the dipolar relaxation [3].

T2 relaxometry measures transverse relaxation times using a multi-echo spin echo sequence that provides a set of images at a fixed sampling rate along an exponential decay curve. The shorter the echo times and the longer the echo train length (number of echoes) the better we can characterize the signal decay and disentangle the contribution of the different tissues. T2* relaxometry uses more rapid sequences with GRASE readout schemes to achieve shorter echo times (sampling rate) yet under the influence of magnetic field inhomogeneities.

Considering the fact that the brain possesses several water pools with various T2, resp. T2* constants, many algorithms have been developed to quantify these distributions and the fraction of the different pools [4] notably the fraction of myelin in each voxel [5].

Among the different existing quantitation methods, some postulate that brain tissue can be separated in three different pools: water trapped in the myelin sheaths (T2<40ms), intra-extra cellular water (40<T2<100ms) and cerebrospinal fluid (CSF) (T2>1s), that can be modeled as Gaussians with a mean T2 and standard deviation[6] . Some other methods consider 40 compartments and are less dependent on the initialization, i.e. the T2 distribution a priori [7].

To estimate those different multicompartment models, some regularization is necessary. All these algorithms have in common that they fix a large number of Diracs along the T2 spectrum and estimate the weight of each of the pikes, usually through a non-negative least squares method (NNLS) [8]. Nagtegaal et al. proposed also to add a sparsity constraint on NNLS algorithm to restrict T2 distribution, decreasing the noise impact and improving computation time by limiting the number of components per voxel processed

[9].

Interestingly, similar questions arise when characterizing other biological samples such as plants. In this case, multi-exponential T2 MRI is used to extract information about the distribution of water in the main subcellular compartments (vacuole, cytoplasm, cell wall) of the tissue [12], [13]. This information is very important for quality control during storage, drying and processing of plants. In the context of biological applications, a dedicated MR pulse sequence, enabling sampling from the beginning to the end of the decay curve, has been developed on the PRISM platform [14] to increase the accuracy of tissue characterisation. Adaptations of the sequence allow optimizing the radiofrequency pulse, add crusher gradients to annihilate the stimulated echoes and increase the number of echoes. The aim is to improve and test the quantification algorithms and then integrate them into existing software solutions.

References :

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[3] O. M. Girard, V. H. Prevost, G. Varma, P. J. Cozzone, D. C. Alsop, et G. Duhamel, « Magnetization transfer from inhomogeneously broadened lines (ihMT): Experimental optimization of saturation parameters for human brain imaging at 1.5 Tesla », *Magn. Reson. Med.*, vol. 73, nº 6, p. 2111‑2121, juin 2015, doi: 10.1002/mrm.25330.

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[14] H. Adriaensen, M. Musse, S. Quellec, A. Vignaud, M. Cambert, et F. Mariette, « MSE-MRI sequence optimisation for measurement of bi- and tri-exponential T2 relaxation in a phantom and fruit », *Magn. Reson. Imaging*, vol. 31, nº 10, p. 1677–1689, déc. 2013, doi: 10.1016/j.mri.2013.02.004.

Assignment

The major scientific objective for this PhD will be to develop and validate an optimized myelin sensitive acquisition and processing approach feasible in a clinical research context, to allow a better understanding of the brain tissue changes in different neurodegenerative diseases. To do so, the PhD student will develop approaches to measure T2 relaxometry and quantify myelin and inter-intra cellular fractions. This approach is particularly promising to shed new light on the brain microstructure.

Also, as part of a collaboration with Dr Musse and Dr Collewet from the OPAALE Team at Inrae, we have started transferring the MR pulse sequence developed by PRISM for use on our clinical research scanner, but further use requires optimisation of the acquisition and processing parameters.

At the same time, the recruited person will consider other acquisition techniques such Magnetization Transfer (ihMT) which focus on the dipolar relaxation. In myelinated structures, the dipolar order relaxation is slower than in other structures, allowing us to achieve a better sensitivity to myelin changes.

Then, the PhD student will apply the developed approach on two cohorts (ongoing data collection): the first one including patients suffering from Alzheimer’s and Parkinson diseases and the second one of patients with multiple sclerosis. The clinical aim is to assess the effectiveness of this candidate disease-specific biomarker and confront it with the other quantitative MR imaging techniques.

Main activities

The position will require evaluation of available methods, suggestions for improvements, optimisation of the acquisition protocol, integration and testing of algorithms in conjunction with existing software infrastructure (anima.irisa.fr), development and implementation of tailor-made solutions based on the needs expressed.

The candidate will also have to become familiar with the existing litterature and present his work in conferences and journal papers as part of the PhD work.

Skills

The applicant should present a good background in physics and applied mathematics. Basic knowledge in image processing would be a plus. Good knowledge of computer science aspects is also mandatory, especially in Python and Matlab. Also good communication skills will be appreciated.

Benefits package

- Restauration subventionnée
- Transports publics remboursés partiellement
- Possibilité de télétravail à hauteur de 90 jours annuels
- Prise en charge partielle du coût de la mutuelle

Remuneration

Salaire mensuel brut de 2 100 € les deux premières années et 2 190 € la troisième

General Information

- **Theme/Domain :** Computational Neuroscience and Medicine
  Scientific computing (BAP E)

- **Town/city :** Rennes
- **Inria Center :** Centre Inria de l'Université de Rennes
- **Starting date :** 2024-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2024-09-30

Contacts

- **Inria Team :** EMPENN
- **PhD Supervisor :**
  Bannier Elise / Elise.Bannier@irisa.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

The keys to success

We look for a candidate strongly motivated by this challenging research topics in MR physics and image processing and looking forward to pursuing a PhD in the field of neuroimaging and quantitative imaging.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

Merci de déposer en ligne CV, lettre de motivation et éventuelles recommandations

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.