3-year postdoc fellow position at NeuroSpin (France), immediately available

TOPIC: High-spatiotemporal resolution SPARKLING fMRI imaging on humans at 11.7T

Supervision:
Dr Philippe Ciuciu, Head of Inria-CEA MIND team
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Key points:

- Duration: 3 years starting as soon as possible.
- Salary: commensurate upon background and experience
- Location: The candidate will be hired by NeuroSpin at CEA Saclay.
- Application: Please send an application with a CV, a motivation letter, a list of publications and 2 letters of recommendation to: philippe.ciuciu@cea.fr

Description:

The **CEA Paris-Saclay** complex is a leading research and innovation center at the national and European level. It is part of the Community of Universities and Establishments "Université Paris-Saclay" which represents approximately 15% of French research. **NeuroSpin** is Europe's main platform for innovation in brain imaging technologies and neuroscience. It was opened on January 1, 2007 and is embedded within the Fundamental Research Division of the CEA. NeuroSpin is headed by Prof. Stanislas Dehaene, (professor at the Collège de France, Paris) and affiliated with **the Paris-Saclay University**. The overarching goal at NeuroSpin is to understand the singularity of human brain with the help of unprecedented tools, such as the unique 11.7T clinical MR system in addition to 7T/3T clinical scanners, which will be soon upgraded for full pTx Terra.X and Cima.X, respectively.

NeuroSpin's organization includes four research units of which the **Inria-CEA MIND and the CEA-CNRS BAOBAB labs** play pivotal roles in the use of AI, signal processing and MR physics for developing new accelerated MR imaging techniques, notably for functional imaging (fMRI).

"**EXPLORE +**" BlueSky project is a large scale CEA-funded project (1.5M€ over 4 years since 2023) awarded to **Dr Philippe Ciuciu, head of the MIND**. The project aims on one hand to understand learning and decision making processes in the healthy brain and to study neuroplasticity and motor recovery mechanisms in Stroke patients during the rehabilitation stage.

The postdoc fellow position will contribute to the first objective of EXPLORE+. In this context, cognitive neuroscientists at NeuroSpin design specific fMRI exploration/exploitation experiments to decipher in each individual the learning and decision making mechanisms that allow the human brain to adapt to cognitive demand via the flexible recruitment of different regions and connections, thus enabling the exploration of an uncertain and changing environment. For this purpose, fMRI experiments will be carried out at 11.7T using the SPARKLING technology (1,2). This 3D non-Cartesian k-space readout, in addition to its strong acceleration potential, embodies very appealing features to allow for high spatial and temporal resolution without impeding whole brain coverage (3). SPARKLING like most of the non-

Cartesian MR acquisition is extremely sensitive to static and dynamic B_0 inhomogeneities. B_0 clip-on-camera (Skope Imaging Technologies, Zurich, Switzerland) has already been used to correct for the ensuing off-resonance artifacts (4).

SPARKLING fMRI acquisition currently requires a computationally-demanding reconstruction process prior to preprocessing fMRI data and carrying out statistical analysis. The first task of the candidate will consist in making the fMRI image reconstruction pipeline easier and faster to make it a reliable off-the-shelf tool for EXPLORE+. For doing so, the candidate will rely first on in-house developments notably the PySAP software package and its plugin for fMRI. Additionally, he/she will investigate deep learning solutions based on unrolled deep learning (5) and Plug&Play algorithms based on past and ongoing works in the MIND team, notably using the SNAKE-fMRI data simulator (6) to train fMRI DL architectures in the supervised learning setting. A very important deliverable will be to implement a complete reconstruction solution directly connected at the console using "Gadgetron" (7) or "Open Recon" Siemens Healthineers platform (8). Automating the correction of off-resonance artifacts within the pipeline is also key.

Importantly, implementation and demonstrations of SPARKLING fMRI have been done at 7T but **EXPLORE+ aims to collect fMRI data at 11.7T** in order to benefit from the larger BOLD contrast to noise ratio. The candidate will also need to adapt the SPARKLING fMRI pulse to 11.7T by adding parallel transmission capabilities with the so-called Universal Pulses (9) to maintain its user-friendly characteristic while delivering homogeneous $B1^+$ RF field. This upgrade should allow us to access layer-specific (500µm) spatial resolution in the cortex. Last, the candidate will participate in fMRI acquisitions and data processing in collaboration with the neuroscientists involved in EXPLORE+.

The ideal candidate holds a PhD in electrical or biomedical engineering, with a solid **background in MRI, signal processing, and Artificial Intelligence (deep learning)** and is proficient in software programming notably in scientific Python. Preliminary experience on supercomputers is a plus.

Since the project requires multiple skills, the candidate will be supported both by Philippe Ciuciu and his team, but also by the BAOBAB (specialized in MRI methodology) and UNICOG (cognitive neuroscience) labs. Therefore he/she must demonstrate team player capabilities. **The position allows partial teleworking and includes social advantages offered to employee working in France** (minimum of 5 weeks of vacations, full healthcare coverage, and free public school for children up to high school).

References:

1. Chaithya GR, Weiss P, Daval-Frérot G, Massire A, Vignaud A, Ciuciu P. Optimizing full 3d sparkling trajectories for high-resolution magnetic resonance imaging. IEEE Transactions on Medical Imaging. 2022 Mar 7;41(8):2105-17.

2. Amor Z, G.R. C, Boulant N, Daval-Frerot G, Thirion B, Mauconduit F, et al. Prospects of non-Cartesian 3D-SPARKLING encoding for functional MRI: A preliminary case study for retinotopic mapping. In: Proceedings of the International Society for Magnetic Resonance in Medicine. London, U.K.; 2022.

3. Amor Z, Comby PA, Ciuciu P, Vignaud A. Achieving high temporal resolution using a sliding-window approach for SPARKLING fMRI data: A simulation study. In: Proceedings of the International Society for Magnetic Resonance in Medicine. Singapore, Singapore; 2024.

4. Amor Z, Le Ster C, Gr C, Daval-Frérot G, Boulant N, Mauconduit F, Thirion B, Ciuciu P, Vignaud A. Impact of ΔB0 field imperfections correction on BOLD sensitivity in 3D-SPARKLING fMRI data. https://onlinelibrary.wiley.com/doi/full/10.1002/mrm.29943;

5. R CG, Ramzi Z, Ciuciu P. Hybrid learning of Non-Cartesian k-space trajectory and MR image reconstruction networks [Internet]. arXiv; 2021 [cité 27 avr 2024]. Disponible sur: http://arxiv.org/abs/2110.12691

6. Comby PA, Vignaud A, Ciuciu P. SNAKE-fMRI: A modular fMRI data simulator from the space-time domain to k-space and back. arXiv preprint arXiv:2404.08282. 2024 Apr 12.

7. Gadgetron: An open source framework for medical image reconstruction - Hansen - 2013 - Magnetic Resonance in Medicine - Wiley Online Library [Internet]. [cité 27 avr 2024]. Disponible sur: https://onlinelibrary.wiley.com/doi/10.1002/mrm.24389

8. Siemens Healthineers presents two revolutionary high-end MRI scanners for clinical and scientific use [Internet]. Disponible sur: https://www.siemens-healthineers.com/press/releases/cimaterrax

9. Gras V, Vignaud A, Amadon A, Le Bihan D, Boulant N. Universal pulses: A new concept for calibration-free parallel transmission. Magnetic Resonance in Medicine. févr 2017;635-43.