INRIA Parietal Team CEA CosmoStat Lab
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2D/3D Magnetic Resonance Image Reconstruction using Geometric Multiscale Decompositions

Research theme: Compressed Sensing & image reconstruction in Magnetic Resonance Imaging.

Duration/Salary: 4 to 5 months (around 800€/month), starting on April 2017.

Teams: INRIA/CEA Parietal team (NeuroSpin) and CosmoStat Lab (CEA Saclay, Ormes des Merisiers).

Advisors: Philippe Ciuciu (`philippe.ciuciu@cea.fr`, +33 1 6908 7785) and Jean-Luc Starck (`jstarck@cea.fr`).

Localization: The successful candidate will be based at NeuroSpin.

Application: Interested candidates should send their CV and motivation letter to the advisors.

Research topic: In biomedical imaging, the advent of Magnetic Resonance Imaging (MRI) strongly impacted medicine and neuroscience. MR image resolution improvement in a standard scanning time (e.g., 400 μm isotropic in 15 min) would allow neuroscientists and doctors to push the limits of their current knowledge and to significantly improve both their diagnosis and patients' follow-up. This could be achieved thanks to the recent Compressed Sensing (CS) theory, which has revolutionized the way of acquiring data by overcoming the Shannon-Nyquist criterion. This breakthrough has been accomplished by combining three key ingredients: (i) variable density sampling, (ii) image representation using sparse decompositions (e.g., wavelets) and (iii) nonlinear image reconstruction using for instance proximal gradient methods (e.g., FISTA). Using CS, data can be massively under-sampled by a given acceleration factor R while ensuring conditions for optimal image recovery.

The COSMIC project in which the current internship proposal holds aims at fostering new interactions between signal/image processing experts in MRI at NeuroSpin (Parietal team) and astrophysicists (CosmoStat lab in CEA) who have so far developed skills in CS separately.

The goal of the present internship is three-fold:

1. Make use of rich multiscale decompositions (e.g., 2D/3D curvelets) proposed by the CosmoStat Lab instead of wavelets and measure their impact on image quality in terms of quantitative metrics (SNR, SSIM ...). Assess the potential gain offered by anisotropic decomposition such as shearlets.
2. Adapt the recently proposed primal-dual optimization algorithm by Condat & Wu, which was recently customized by the CosmoStat Lab for image restoration in cosmology, to the MRI set-up (complex-valued data, multichannel acquisition, 3D imaging ...).
3. Validate on both simulations and real data collected on the 7T MRI scanner at NeuroSpin.

Skills. We look for efficient candidates strongly motivated by challenging research topics. The applicant should present a good background in signal processing including wavelet theory, optimization and computer science. Basic knowledge in MRI would be a plus. As regards software developments, `C`, `Python` or `Matlab` languages are preferred.

Keywords. Compressed Sensing, MR image reconstruction, optimization, curvelets, shearlets.