PySAP-MRI: A Python Package for MR Image Reconstruction

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ISMRM workshop on Data sampling & Image reconstruction
Sedona, AZ, USA – Jan. 26\textsuperscript{th} - 29\textsuperscript{th}, 2020
Declaration of
Financial Interests or Relationships

Speaker Name: Philippe Ciuciu

I have no financial interests or relationships to disclose with regard to the subject matter of this presentation.
PySAP: Python Sparse Data Analysis Package

ModOpt

Sparse2D

Cosmic

Compressed Sensing for Magnetic Resonance Imaging & Cosmology

Plug-Ins

https://github.com/cea-cosmic/pysap
Modular Optimization and Sparse Decomposition

\[ \hat{x} = \arg \min_{x \in \mathbb{C}^{N \times N}} \frac{1}{2} \| y - Ax \|_2^2 + \lambda g(\Psi x) \]

Optimization Algorithms
- Forward-Backward
- Generalized Forward-Backward
- FISTA
- POGM’
- Condat-Vu

Proximity Operators
- Hard/Soft Thresholding
- Positivity constraint
- Low-Rank Approximation, etc.

Linear Operators
- Sparse2D
- Pywavelets

Cost Function

MRI: \( A = F_{\Omega} \)

Regularization: \( g(\cdot) = \| \cdot \|_1, \| \cdot \|_{\ast}, \| \cdot \|_{2,1}, \cdots \)
Goal: Implement various MRI reconstruction models

- **Modeling Features**
  - Cartesian and non-Cartesian sampling schemes in operators API
  - Various image acquisition models in reconstructors API:
    - 2D vs 3D imaging
    - single vs multiple channels
    - self-calibrating vs calibrationless

\[
\hat{x} = \arg \min_{x \in \mathbb{C}^{N \times N}} \sum_{\ell=1}^{L} \frac{1}{2\sigma^2_\ell} \| F_{\Omega} S_{\ell} x - y_{\ell} \|_2^2 + \lambda \| \Psi x \|_1
\]

20x accel.

\[
\hat{x} = \arg \min_{x \in \mathbb{C}^{N^2 \times L}} \sum_{\ell=1}^{L} \frac{1}{2\sigma^2_\ell} \| F_{\Omega} x_{\ell} - y_{\ell} \|_2^2 + \lambda g_{\text{OSCAR}}(\Psi x)
\]
Open to the Computational Imaging Community

https://github.com/cea-cosmic

- **Software Features**
  - Continuous integration with Travis
  - Automated build of documentation
  - Integration with pyNUFFT for GPU implementation of NFFT
  - Parallelization over multiCPU for calibrationless recon.
  - GPU support in progress

- **Dissemination**
  - Test data sets & Jupyter notebooks provided (Binder support)
  - Connection to pysap-data and pysap-tutorials

- **Upcoming plug-ins**
  - Electron tomography & microscopy