

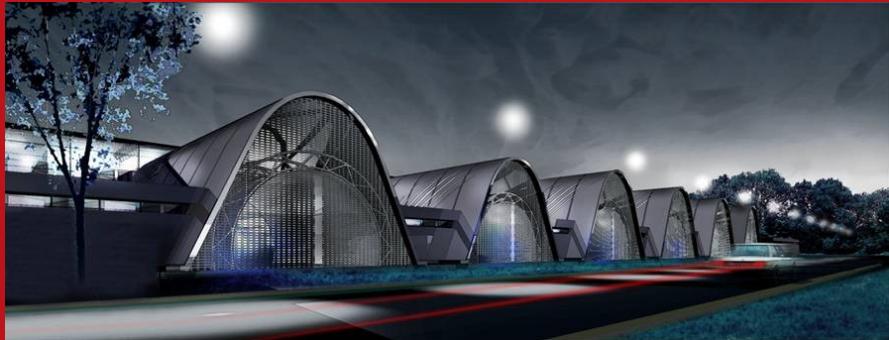
# PySAP-MRI: A Python Package for MR Image Reconstruction

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*ISMRM workshop on Data sampling & Image reconstruction*

*Sedona, AZ, USA – Jan. 26<sup>th</sup> - 29<sup>th</sup>, 2020*

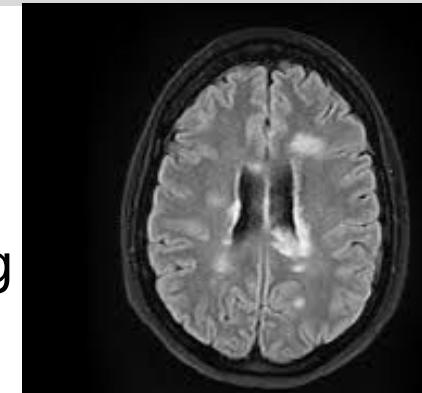
## Declaration of Financial Interests or Relationships

Speaker Name: Philippe Ciuciu

I have no financial interests or relationships to disclose with regard to the subject matter of this presentation.

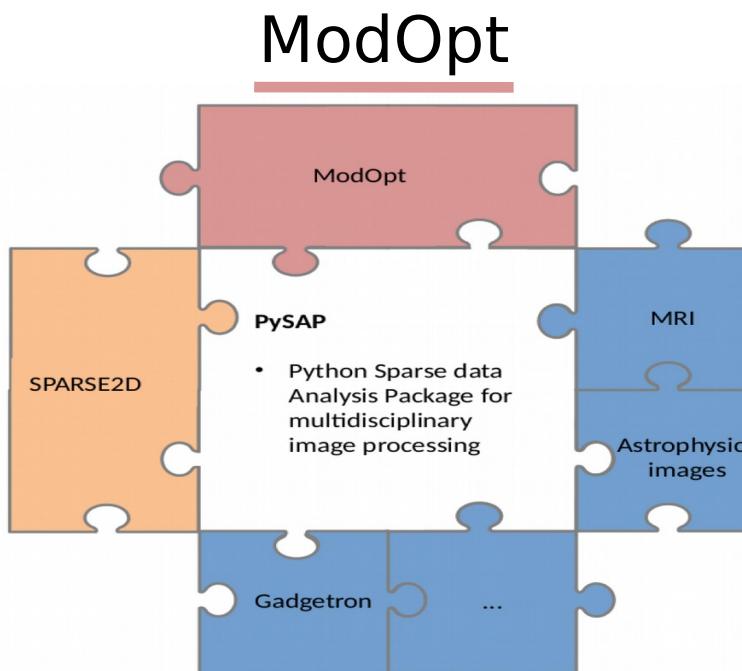


Compressed Sensing for Magnetic Resonance Imaging & Cosmology



PySAP: Python Sparse Data Analysis Package

Sparse2D



Plug-Ins

<https://github.com/cea-cosmic/pysap>

ModOpt

## Optimization Algorithms

- Forward-Backward
- Generalized Forward-Backward
- FISTA
- POGM'
- Condat-Vu

## Proximity Operators

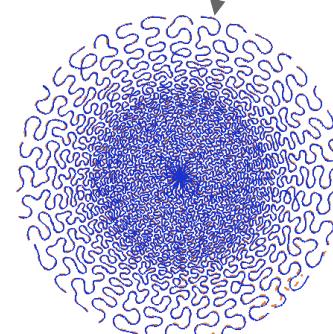
- Hard/Soft Thresholding
- Positivity constraint
- Low-Rank Approximation, etc.

## Linear Operators

- Sparse2D
- Pywavelets

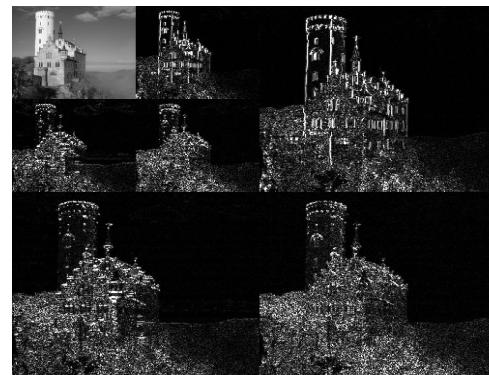
## Cost Function

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

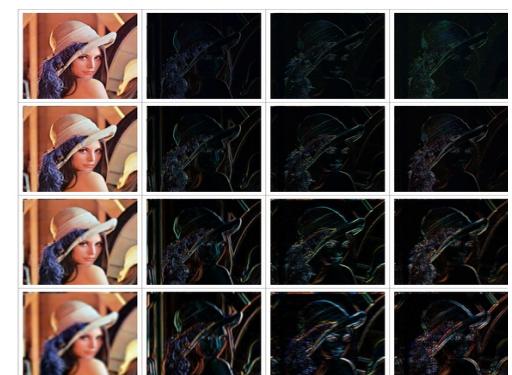


MRI:  $\mathbf{A} = \mathcal{F}_\Omega$

**Sparse2D: Sparse Dictionaries in 1D, 2D and 3D**



Discrete Wavelet transforms



Undecimated Wavelet transforms

**Regularization:**  $g(\cdot) = \|\cdot\|_1, \|\cdot\|_*, \|\cdot\|_{2,1}, \dots$

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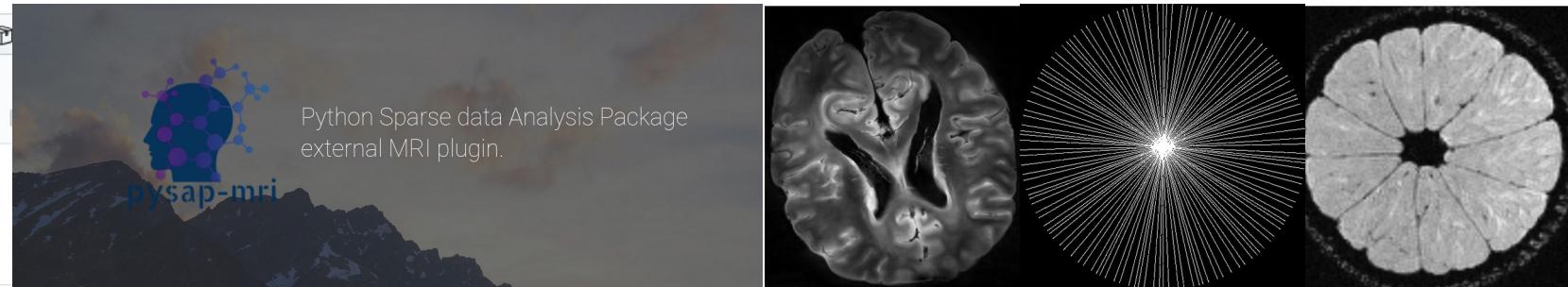
210 commits 2 branches 0 packages 1 release 1 en

Branch: master New pull request Create

chaithyagr Fix all doc errors and warnings (#71) ...

Cartesian Reference Self Calibrating L1-ESPIRiT OSCAR Calibrationless [El Gueddari et. al., IEEE ISBI 2019]

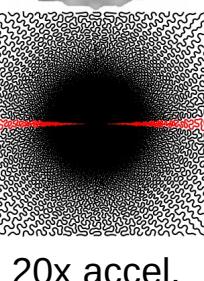
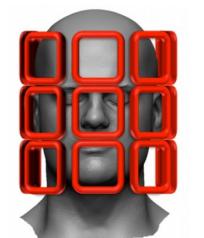
20x accel.



## 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**



$$\hat{\underline{x}} = \arg \min_{\underline{x} \in \mathbb{C}^{N \times N}} \sum_{\ell=1}^L \frac{1}{2\sigma_\ell^2} \|\mathbf{F}_\Omega \mathbf{S}_\ell \underline{x} - \mathbf{y}_\ell\|_2^2 + \lambda \|\Psi \underline{x}\|_1$$

$$\underline{\hat{x}} = \arg \min_{\underline{x} \in \mathbb{C}^{N^2 \times L}} \sum_{\ell=1}^L \frac{1}{2\sigma_\ell^2} \|\mathbf{F}_\Omega \underline{x}_\ell - \mathbf{y}_\ell\|_2^2 + \lambda g_{\text{OSCAR}}(\Psi \underline{x})$$

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The toy datasets used in the pySAP examples.  
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Modular Optimisation tools for solving inverse problems  
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**pysap-gadgetron**  
Gadgetron MRI reconstruction pipelines derived from pysap.  
1 stars 0 issues 0 forks Updated on 20 Dec 2019

**pysap-astro**  
Python 1 stars 0 issues 0 forks Updated on 25 Sep 2019

**pysap-extplugin**  
Template to create an external plugin for pysap.  
Python 2 stars 0 issues 0 forks Updated on 18 Mar 2019

**Released soon**

**Make your own plugin!**

<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