

Galaxy-Reconstruction-ISTA

This repository contains the implementation of the Iterative Soft Thresholding Algorithm (ISTA) for reconstructing galaxy images from sparse and noisy measurements. The images are sourced from the DESI Legacy Imaging Surveys (DECaLS).

Overview

In this project, we implement a compressed sensing method, namely ISTA, to reconstruct DESI Legacy Imaging Surveys images of spiral galaxies from sparse and noisy measurements. The method iteratively minimizes the Lasso optimization problem to achieve this.

Requirements

To run the code, you need to have the following packages installed:

- `numpy`
- `scipy`
- `h5py`
- `pywt`
- `tqdm`
- `matplotlib`

Summary of Tasks

- 1. Loading, Inspecting, and Preparing Data:**
 - Load the galaxy image data.
 - Select and preprocess a single galaxy image.
 - Add Gaussian noise to the image.
 - Randomly subsample the noisy image.
- 2. Transforms:**
 - Implement Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT).
- 3. ISTA Algorithm:**
 - Implement the ISTA iterative scheme for image reconstruction.
 - Define the soft thresholding function.
 - Write the function for executing a single ISTA step.
- 4. Reconstruction:**
 - Reconstruct the galaxy image using the ISTA method.
 - Plot and compare the original, noisy, subsampled, and reconstructed images.
- 5. Analysis:**
 - Extend the ISTA method to output the number of non-zero coefficients.
 - Compare the results using different bases (DCT and DWT).

Results

The notebook includes detailed plots and analysis of the original, noisy, subsampled, and reconstructed galaxy images. The performance of the ISTA method is evaluated based on the reconstruction error and sparsity of the solution.