Computational imaging

Non-local sparse model for image restoration

Summary

1. Dataset and evaluation method
2. Non-local means filtering for image denoising
3. Learned sparse coding
4. Comparison of both methods

1. Dataset and evaluation methods

Dataset : samoyed-data

Evaluation method :

- Peak signal to noise ratio (psnr)
- mean square error

- We considered Gaussian noise as a fair noise for our benchmark. As it is the most common modelisation of the real noise (due to *Central limit theorem*)

2. Non-local means filtering for image denoising

Idea : Using self similarities of patches within the image to denoise it

Implementation :

$$u(p) = \frac{1}{C(p)} \sum_{q \in \Omega} v(q) f(p,q)$$

$$C(p) = \sum_{q \in \Omega} f(p,q)$$

$$f(p,q) = e^{-\frac{|B(q)-B(p)|^2}{h^2}}$$

$$B(p) = \frac{1}{|R(p)|} \sum_{i \in R(p)} v(i)$$

u : filtered value

v : noisy value

C(p) : normalizing factor

f(p,q) : Gaussian weighting

B(p) : mean of a patch

R(p) : patch image

Parameters of the method :

h : bandwidth
s : size of a patch
S : size of the region of interest

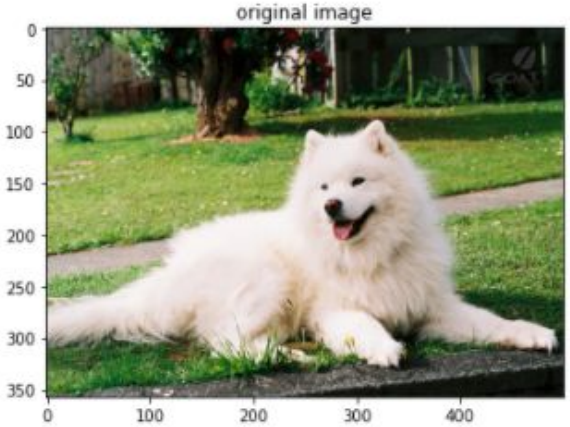
2. Non-local means filtering for image denoising

```
noisy psnr:  20.731663178889484

denoised psnr 23.515003570592185
noisy mse:  549.4321176470588

denoised mse 289.45429878618114
```

Parameters: h = 4
s = 4
S = 10



3. Learned sparse dictionary for image denoising

Idea : Learning a dictionary D of size m*k.

$$\min_{\mathbf{D}\in\mathcal{C},\mathbf{A}} \sum_{i=1}^{n} ||\boldsymbol{\alpha}_i||_p \ \text{ s.t. } \ ||\boldsymbol{y}_i - \mathbf{D}\boldsymbol{\alpha}_i||_2^2 \leq \varepsilon,$$

Learning set : noisy patches from considered image

m : patches size

k : number of elements in D

y_i : noisy patche

p-norm : sparsity-inducing

Image reconstitution :

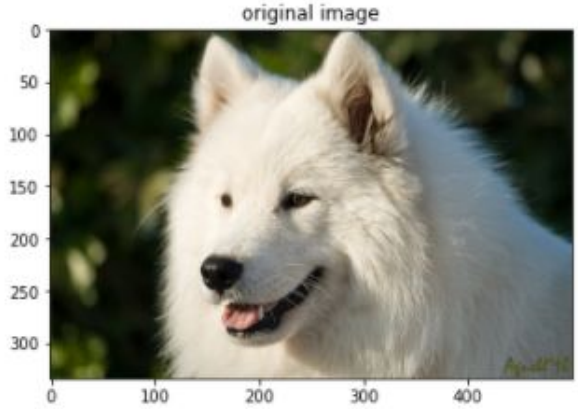
$$\boldsymbol{x} = \frac{1}{m} \sum_{i=1}^{n} \mathbf{R}_i \mathbf{D}\boldsymbol{\alpha}_i,$$

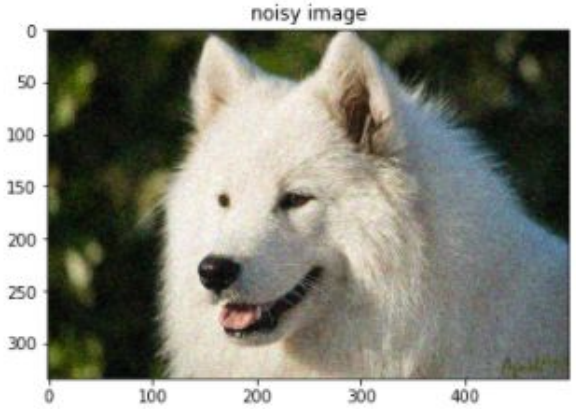
Results

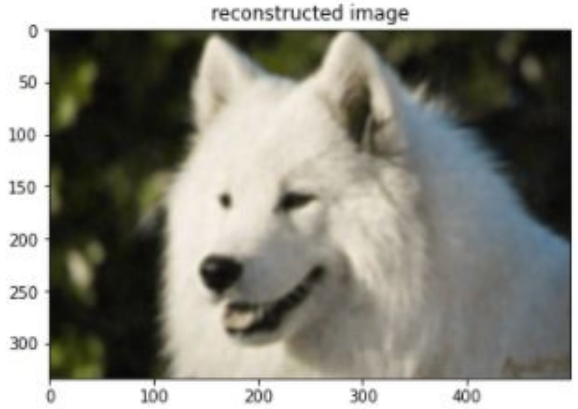
```
noisy psnr:  5.831935340305726

denoised psnr 26.76744316118466
noisy mse:  16978.011633832593

denoised mse 136.87875449101796
```



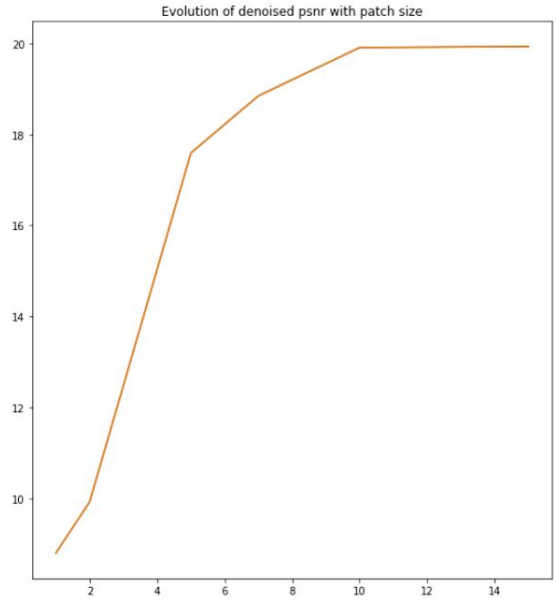




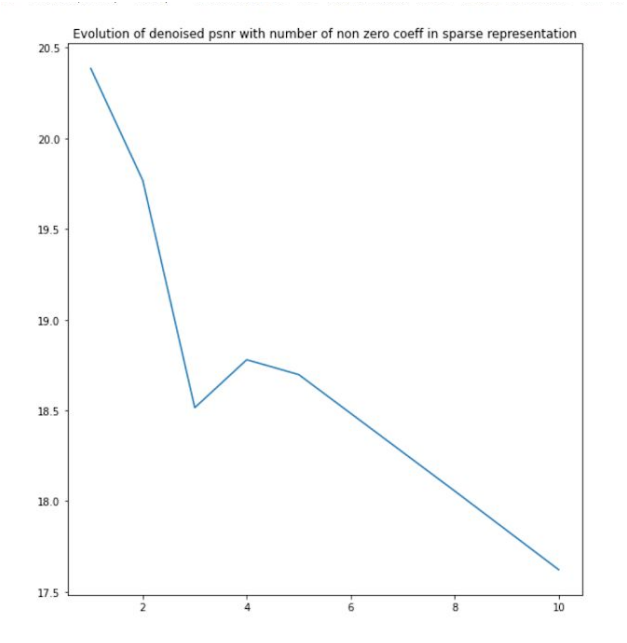
Influence of parameters

Comparison method: peak signal to noise ratio.

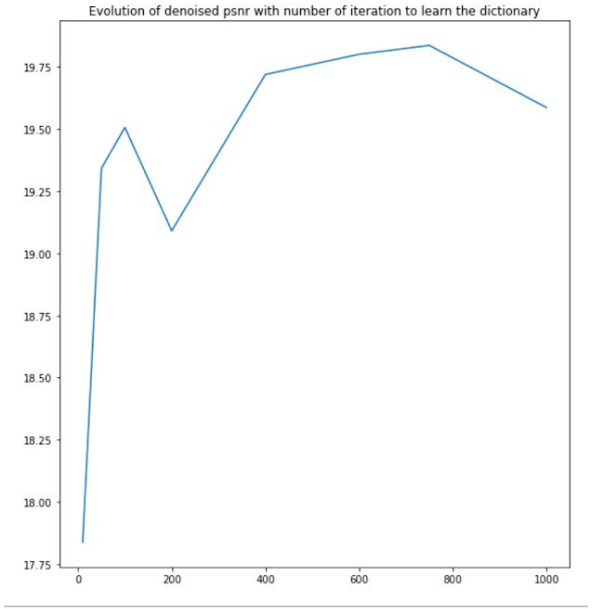
Patch size



Non zero coefficient in sparse decomposition

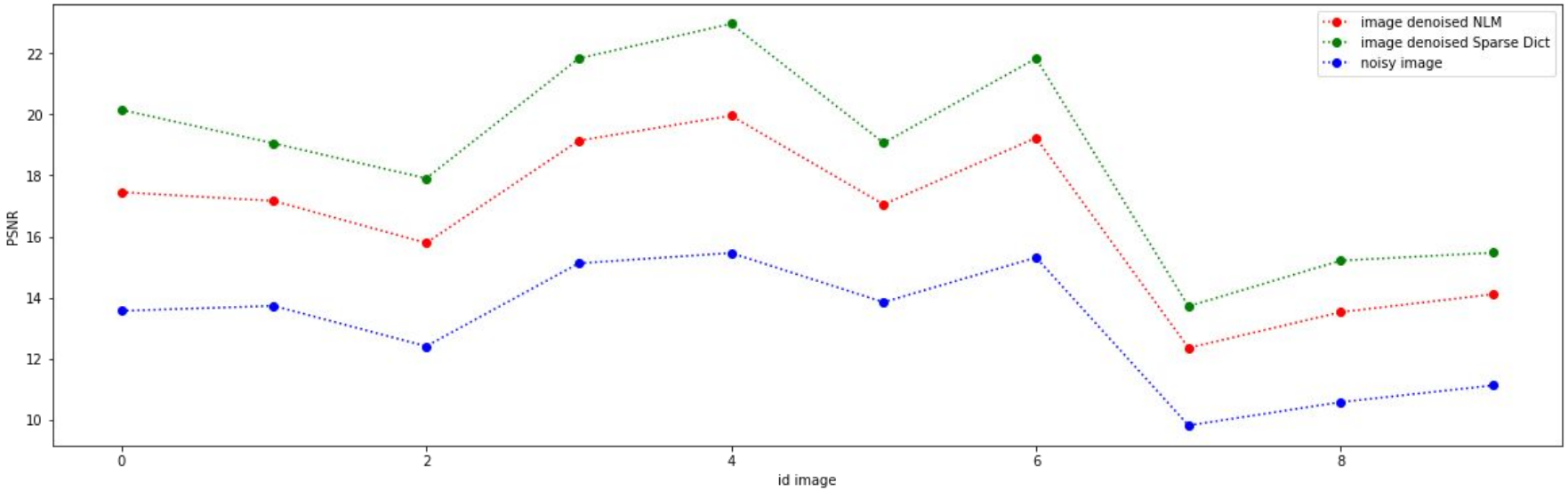


Iteration to learn dictionary



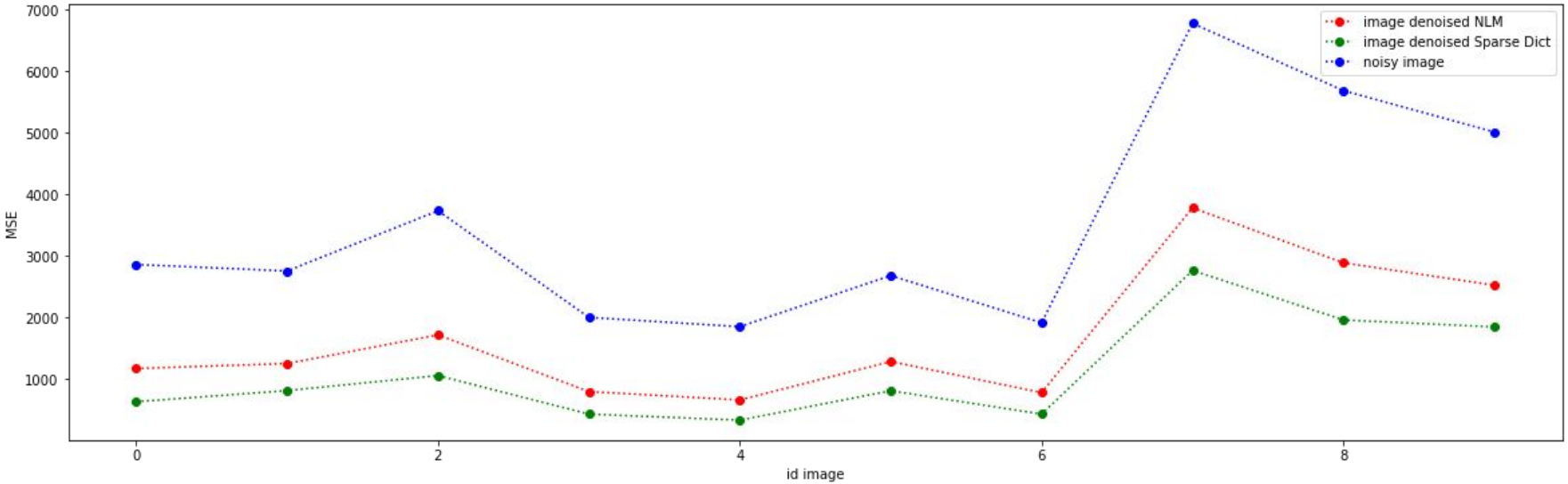
4. Comparison of both methods

- Peak signal noise ratio (psnr)



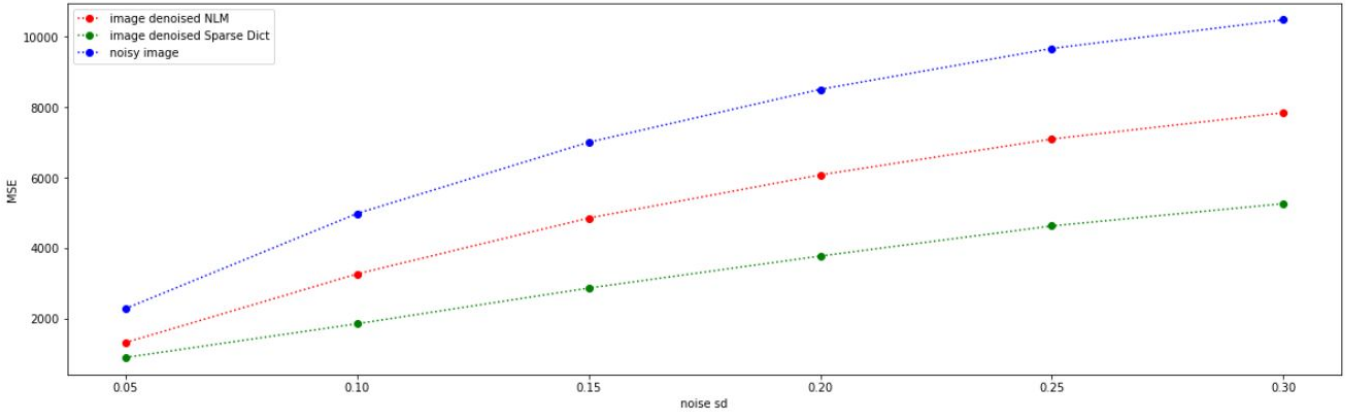
Comparison of both methods

- Mean Square Error (MSE):

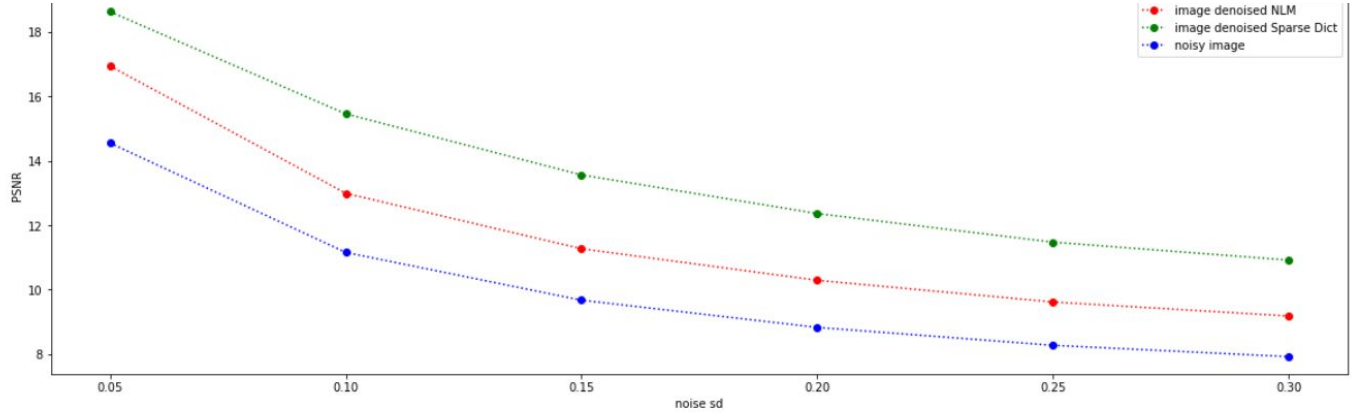


Comparison of both methods

MSE



PSNR



Comparison of both methods

- Time aspect:
    - to have some decent recent with the NLM → ~ 4 to 5 minutes per image
    - for the sparse dictionary → 1 to 2 minutes per image