Traitement d’images

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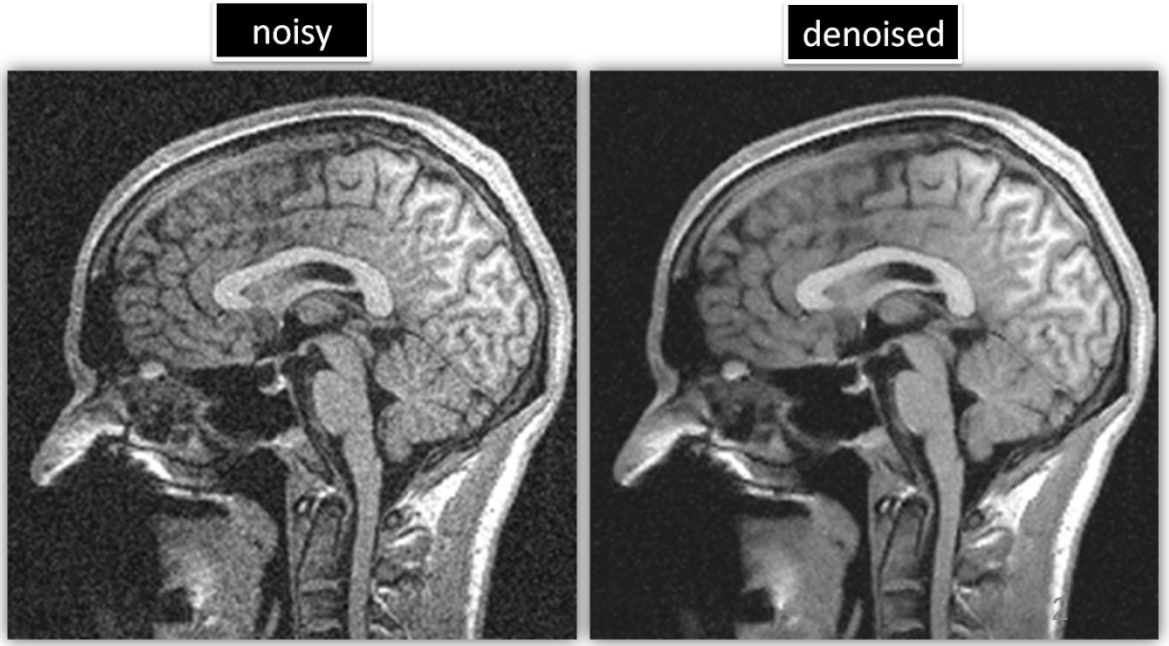
Restauration et débruitage



http://www.cs.utah.edu/~suyash/pubs/denoising_mri/

Restauration et débruitage

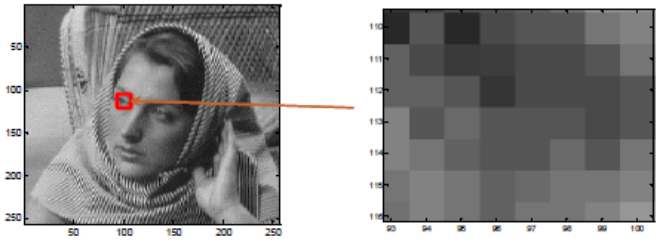
- Par filtrage spatial linéaire
  - Le filtre est représenté par un masque 3x3 (aussi appelé noyau, fenêtre, window)

$$g(x,y) = \sum_{i=-1}^{1} \sum_{j=-1}^{1} h(x-i, y-j) f(i,j)$$

Un pixel f(i,j) est remplacé par une somme pondérée de lui-même et des pixels de son voisinage

Filters

- A filter is a process that removes or enhances some feature of an image.
- Commonly, the word "filter" describes an operation on the *neighborhood* of an image.



Linear Filters

- A linear filter is a neighborhood operation that can be written as a convolution.

$$g(x,y) = (f * w)(x,y)$$
$$= \sum_m \sum_n f(m,n)w(x-m, y-n)$$

- f = original image
- w = filter
- g = filtered image

Linear Filters

- Digitally, we slide the filter w around the image f and compute the weighted average of that neighborhood.
- We usually choose the filter to have size NxN where N is odd.

W=

w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

f =

f_1	f_2	f_3	f_4	f_5
f_6	f_7	f_8	f_9	f_{10}
f_{11}	f_{12}	f_{13}	f_{14}	f_{15}
f_{16}	f_{17}	f_{18}	f_{19}	f_{20}
f_{21}	f_{22}	f_{23}	f_{24}	f_{25}

$$g_{13} = w_1f_7 + w_2f_8 + w_3f_9 + w_4f_{12} + w_5f_{13} + w_6f_{14} + w_7f_{17} + w_8f_{18} + w_9f_{19}$$

- The boundaries have to be handled carefully.

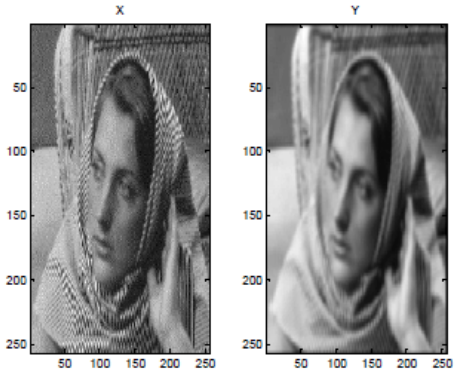
Mean Filter

- For example, we could choose the 3x3 *mean (box) filter*.
- Note we generally normalize the weights to one to preserve the overall gray level of the image.

$$w = \frac{1}{9}\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix}$$

- The Matlab command *imfilter* performs convolutions.

```
load woman;
w=1/9*ones(3,3);
Y=imfilter(X,w);
```



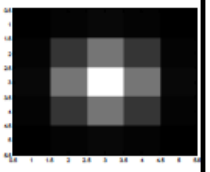
Gaussian Filter

- To put more emphasis on the center pixel, we could make a digital *Gaussian filter*:

$$G = \frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

- The Matlab command *fspecial* can build filters.

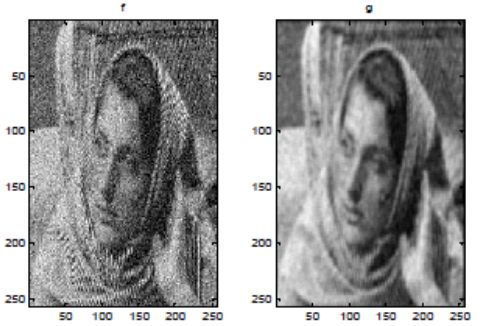
```
G = fspecial('gaussian',[5,5],0.8)

G =
    0.0005    0.0050    0.0109    0.0050    0.0005
    0.0050    0.0522    0.1141    0.0522    0.0050
    0.0109    0.1141    0.2491    0.1141    0.0109
    0.0050    0.0522    0.1141    0.0522    0.0050
    0.0005    0.0050    0.0109    0.0050    0.0005
```



Gaussian Filter

- Although a Gaussian filter is good at removing Gaussian noise, it also blurs the image.

```
load woman;
f = imnoise(uint8(X),'gaussian', 0, 0.02);
G = fspecial('gaussian', [5,5], 0.5)
g = imfilter(f,G);
```



Median Filter

- The median filter computes the median of the neighborhood centered over the pixel.
- Compared to the mean filter, the median filter preserves edges better.

255	255	0
255	100	0
255	255	0

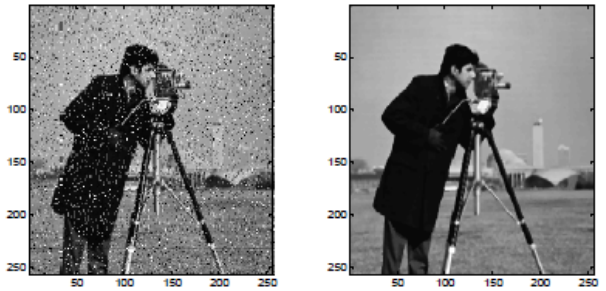
Mean = 152.8

Median = 255

Median Filter

- The median filter and its variants are well-suited for salt & pepper noise.
- The Matlab command *nlfilter* calculates nonlinear functions on neighborhoods. It is much slower than imfilter.

```
B = nlfilter(A, [3,3], @(x) median(x(:)) );
```

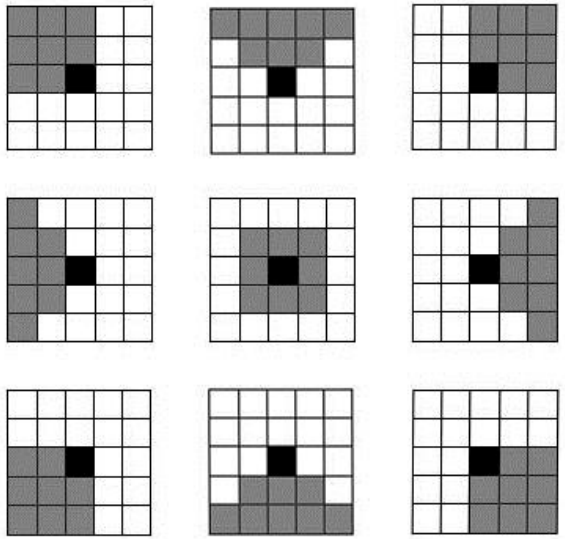


Complexité

- complexité du filtre : nombre d'opérations nécessaires pour calculer sa valeur en chaque pixel de l'image

Autres filtres non-linéaires

- Filtre de Nagao (1979)



Filtre de Nagao

Bruit impulsionnel (densité=2%)

Image filtrée

Filtres non-locaux

- Les filtres vus précédemment utilisent des pixels proches du pixel à estimer (voisinage)

- Ici on cherche des pixels « proches » au sens de l'intensité

- Filtre bilatéral

Un peu de formalisme au tableau…

Filtres non-locaux

- Noisy source image:

Filtres non-locaux

- Gaussian Filter

Low noise,

Low detail

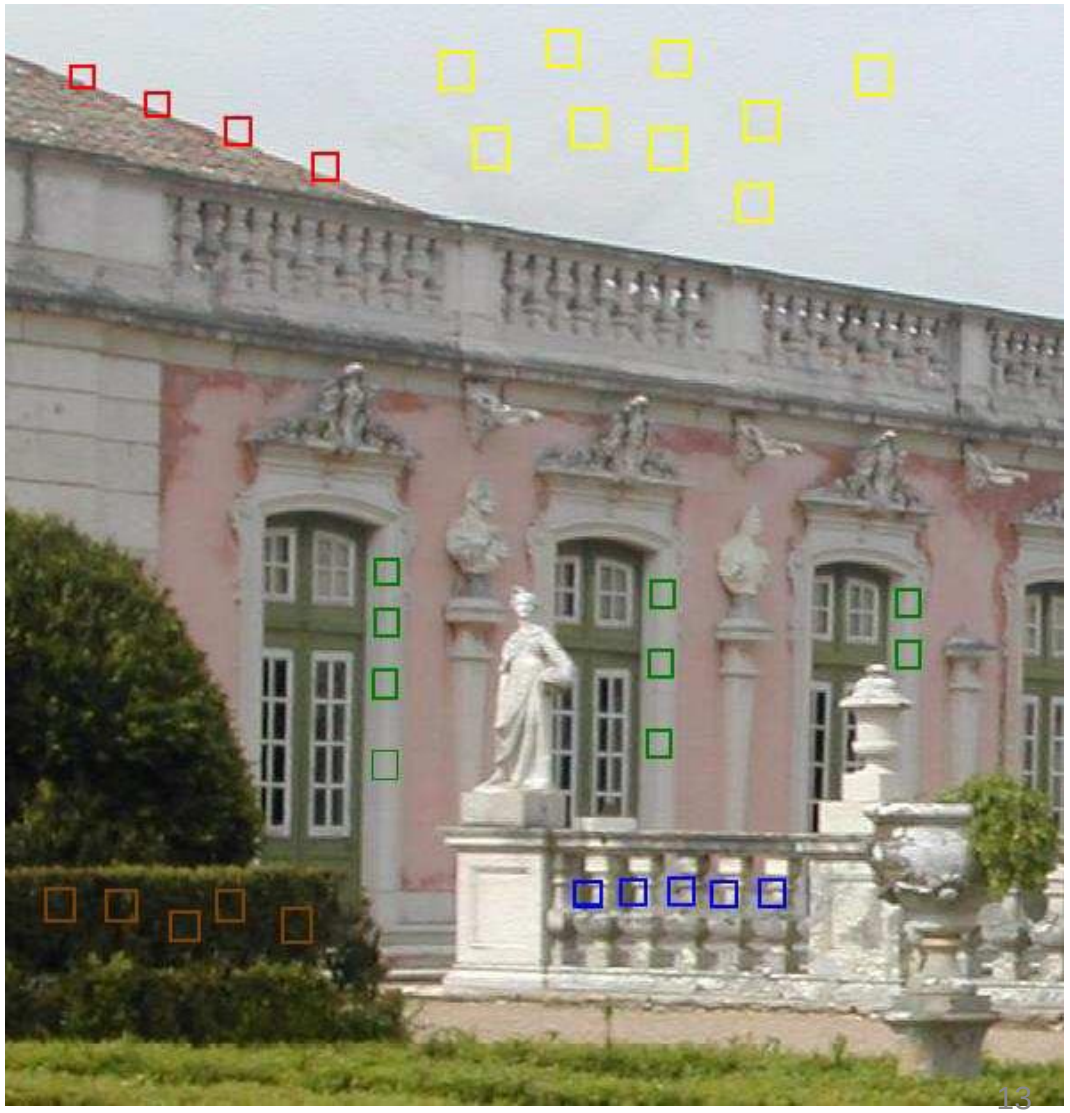
Filtres non-locaux

- Bilateral Filter

Filtre NL Means (2005)

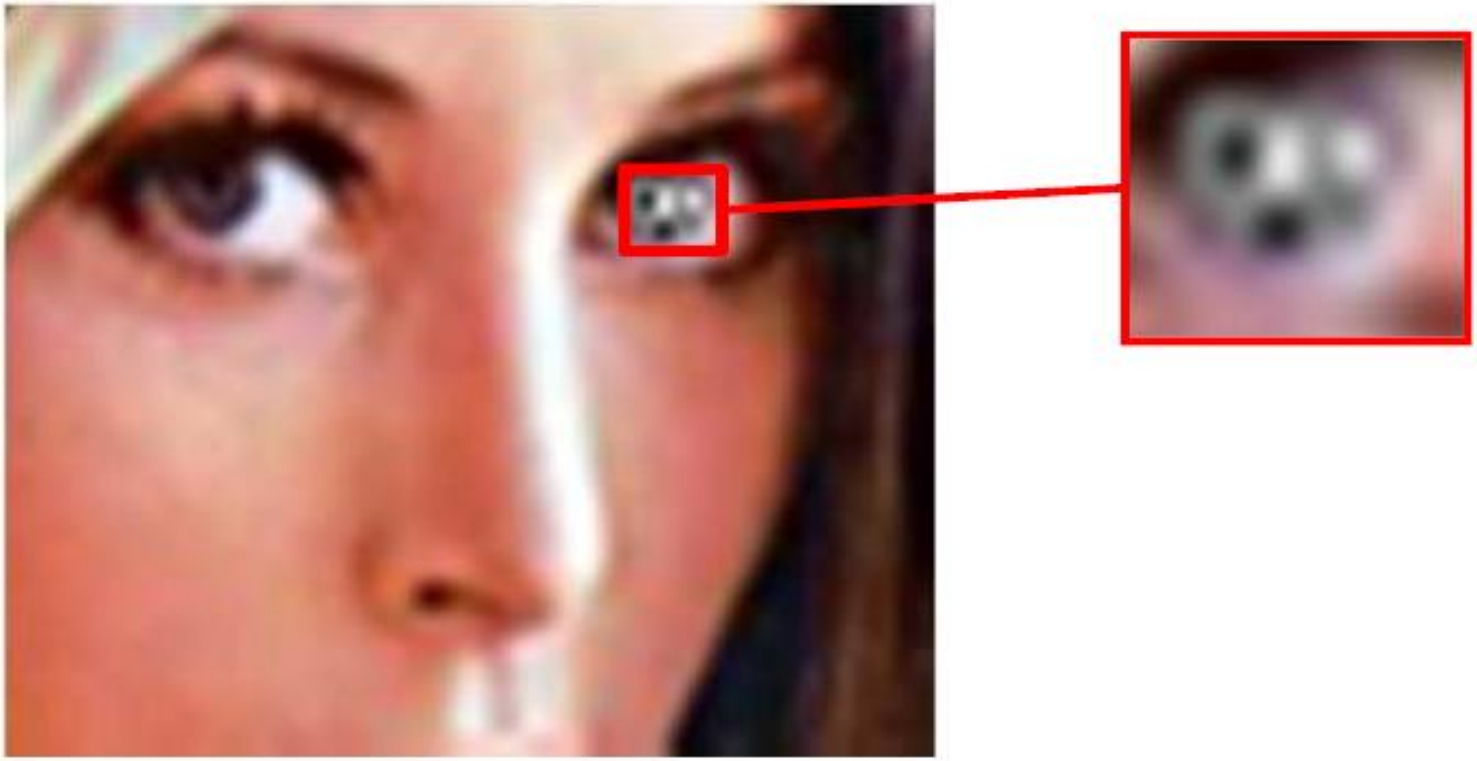
- NL Means :

Chercher non plus des pixels mais des voisinages qui se ressemblent dans toute l'image…



Filtre NL means

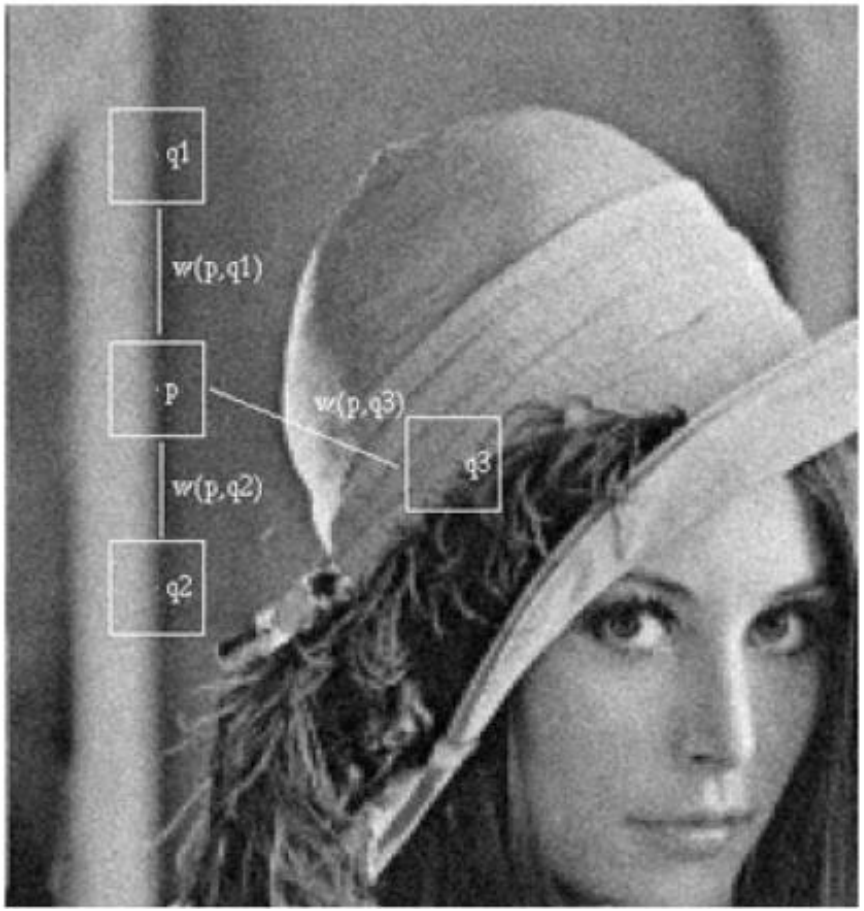
- Suppose Lena's left eye was obscured by noise.
- A neighborhood around the eye will not tell us the eye's true color.



- *Solution*: Look at the other eye!

Filtre NL means

- Natural images tend to have similar neighborhoods.

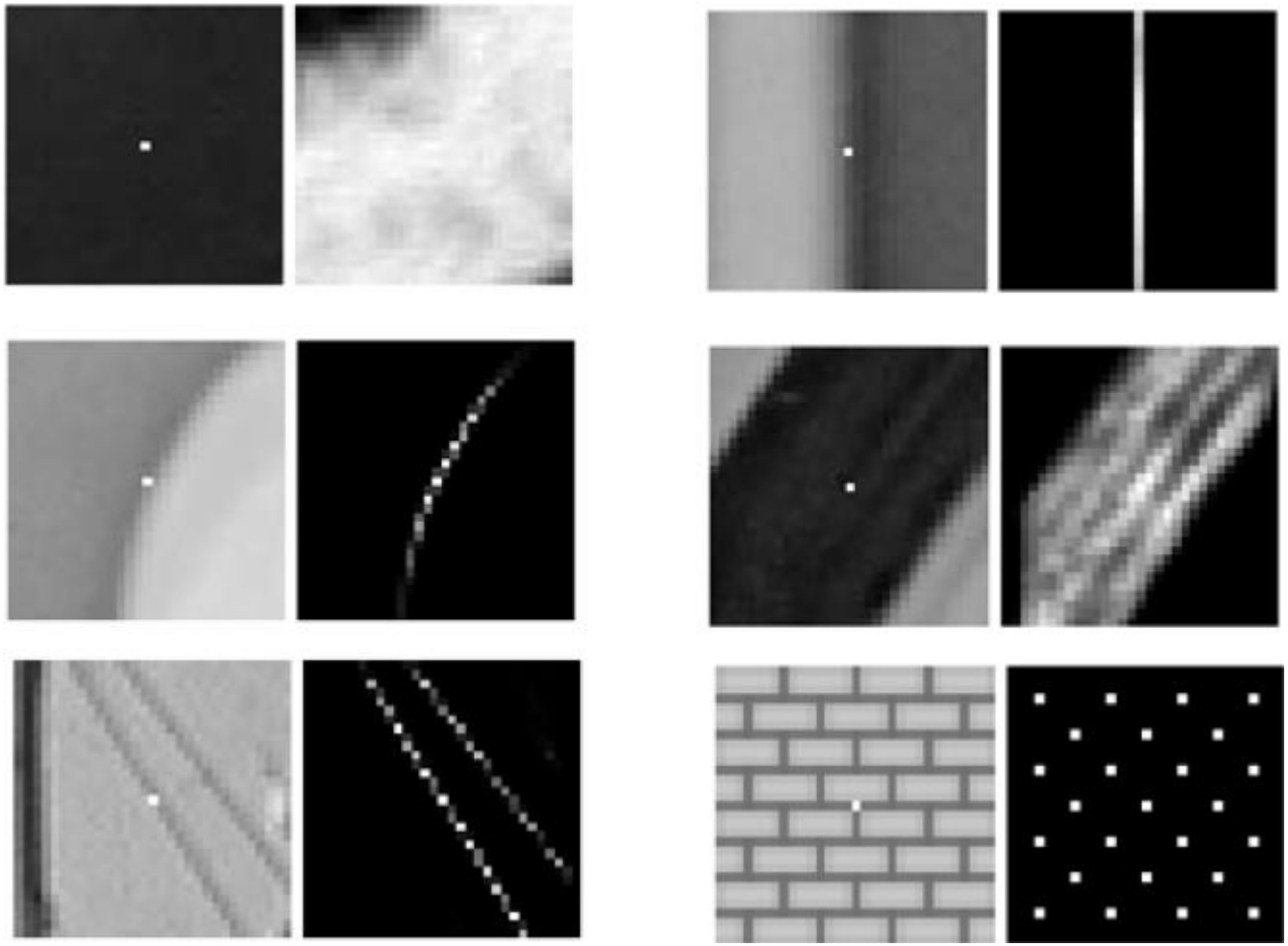


Un peu de formalisme au tableau…

Filtre NL means

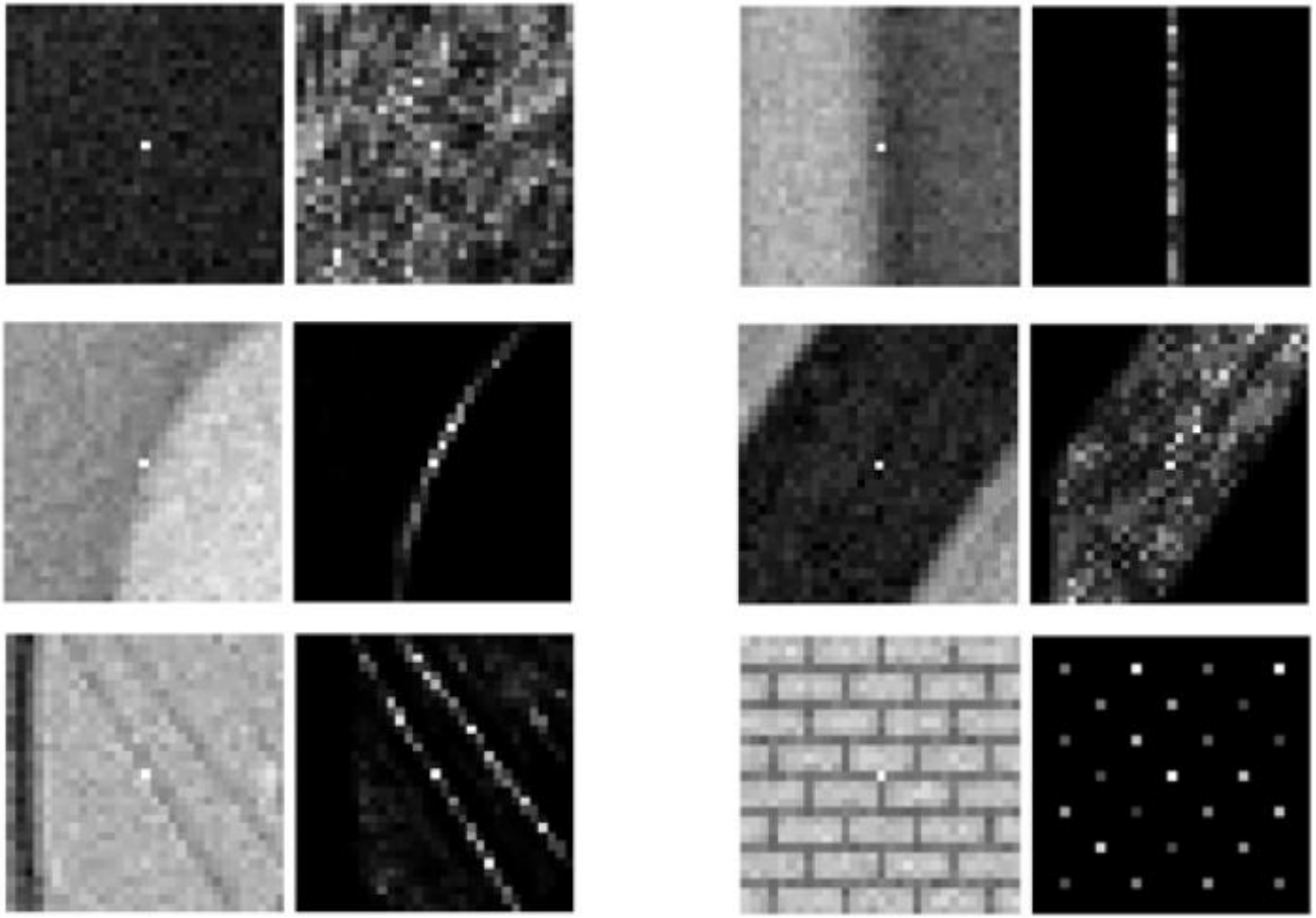
- Poids w(x,p) :

Ils donnent de l'importance aux régions similaires



Filtre NL means

- Poids w(x,p) pour images bruitées

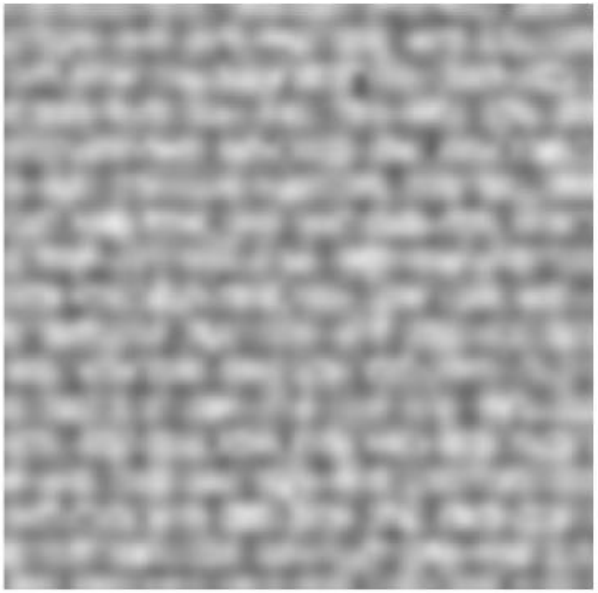


Filtre NL Means

Exemples de résutats

- Comparaison au filtre gaussien

Noisy



Gauss Filtered

NL-Means

Filtres non-locaux

NL-Means Filter (Buades 2005)

- Bilateral Filter

Filtres non-locaux

NL-Means Filter (Buades 2005)

- NL-Means:

Sharp,
Low noise,
Few artifacts.

Filtre NL means

- Débruitage de surfaces

Noisy Mean Curvature Smoothing NL-Means

- Considéré comme le meilleur filtre débruiteur aujourd'hui
- Pb du filtre NL means : très lent…

Références

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- Non local image processing, JM Morel & Capo 2011
- Cours Julien Lefevre, Univ Aix Marseille