

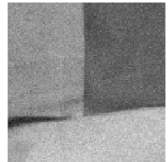
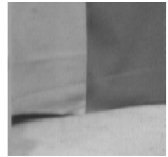
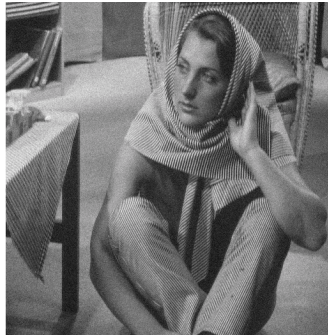
Image processing and nonparametric regression

Rencontres R BoRdeaux 2012

B. Thieurmél

Collaborators : P.A. Cornillon, N. Hengartner,
E. Matzner-Løber, B. Wolberg
2 Juillet 2012





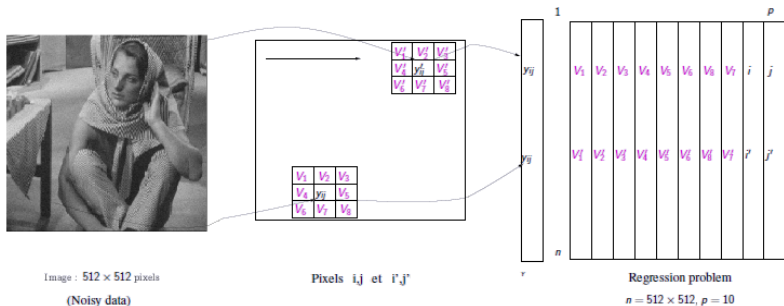
Definition :

- noisy image = original image + noise
- Our study : gaussian noise

- **image** : matrix pixel
- **one pixel**
 - represent a value of grey level or color level
 - is spatially defined by its coordinates (i, j)
 - is surrounded with 8 neighbors (vertical, horizontal and diagonal)
- **numerical measure** : Peak Signal to Noise Ratio (**PSNR**)

$$PSNR = 10 \times \log_{10}\left(\frac{d^2}{MSE}\right)$$

- d maximum possible pixel value of the image
- MSE mean squared error between the original image and the treated image
- quality of reconstruction, in decibel (**dB**)
- well reconstructed image $\rightarrow 30 \leq PSNR \leq 40$



Notations :

- y_{ij} the grey level at pixel (i, j)
- Y the grey level of the pixel to be denoised
- $X \in \mathbb{R}^{10}$ (or more) the vector of explanatory variables

Non parametric regression model :

- $(X_i, Y_i) \in \mathbb{R}^d \times \mathbb{R}$ pairs of observations

$$Y = m(X) + \varepsilon$$

$$\hat{Y} = S_\lambda Y$$

Using method Iterative Bias Reduction (**IBR**) :

- developed by Cornillon, Hengartner et Matzner-Løber
- competes with classic techniques (MARS, GAM)
- estimation without constraints of the regression function m
- **R** package **ibr** available on cran

Problem :

$n = 262144 \rightarrow$ smoothing matrix very big

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Resolution :

Image partitioning in small-sized regions

Our proposal :

- free itself from the choice of the size of regions
- have a certain freedom of shape
- data dependent regions
- use of **CART**(Breiman *et al.*, 1984) and more exactly regression trees
- explain grey level Y by coordinates (i, j)

Modifications of package **rpart** (T.M. Therneau *et al.*, 2002) :

- application for high-dimension data
- control maximum and minimum region size

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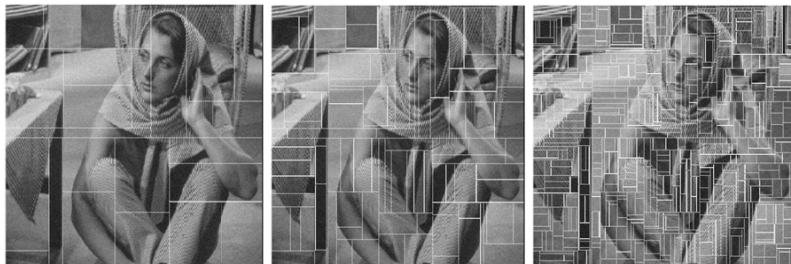
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Modifications of package **rpart** (T.M. Therneau *et al.*, 2002) :

- application for high-dimension data
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- Evolution of partitioning via **rpart** :



Characteristics :

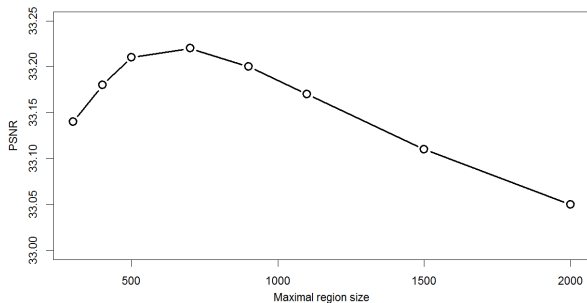
- rectangular regions
- detection of the horizontal and/or vertical structures of the image

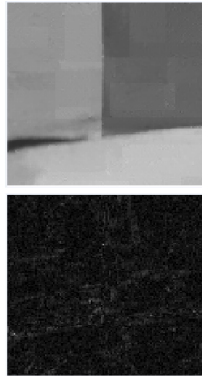
Regression model for each region :

$$Y_i = m(X_i) + \varepsilon_i, \quad i = 1, \dots, n,$$

with $X \in \mathbb{R}^{10}$ the vector of explanatory variables, and n the size of the region

- Question : Influence of the size of regions ?

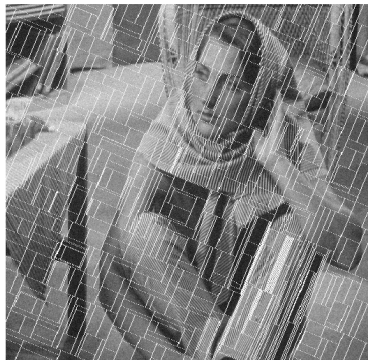




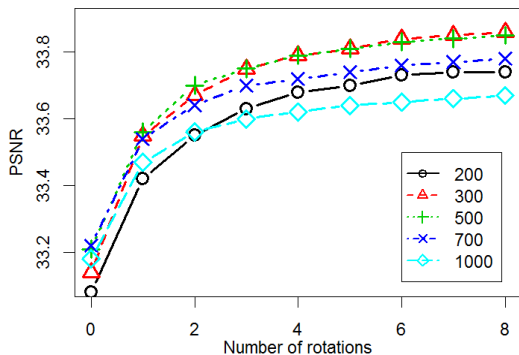
- maximum size of regions : 700 pixels
- number of regions : 686
- region no overlapping → visibility of the outlines of regions
- PSNR = 33.22 dB

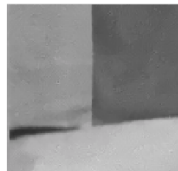
Rotation :

- iteration of image partitioning and image denoising via **IBR**
- rotation of plan IJ between every iteration
- prediction of a same pixel with different regions
- unique prediction : mean of predicted values



- Question : Influence of the number of rotations?





- maximum size of regions : 300 pixels
- number of rotations : 3
- PSNR = 33.75 dB \rightarrow + 0.5 dB

Presentation :

- developed by Dabov *et al.*, 2007
- state of art
- **algorithm** : standard deviation of the noise in parameter
→ strong influence on the result
→ unknown noise, default standard deviation = 25
- source **Matlab** code available

Comparison BM3D / IBR :

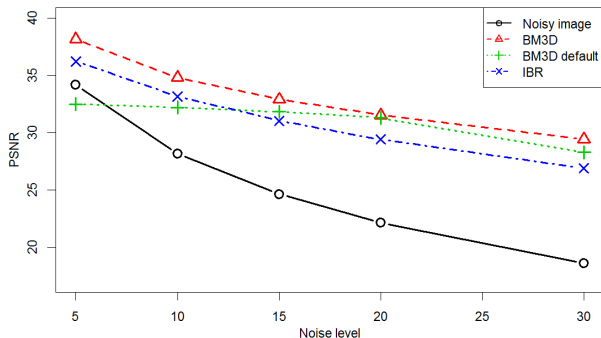
- several images with various noise
- 3 results :
 - ① BM3D with good standard deviation of the noise
 - ② BM3D with default standard deviation of the noise
 - ③ IBR, 3 rotations, maximum size = 700

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- BM3D with good standard deviation of the noise (red) :
 - IBR (blue) less successful of more or less 2 dB
 - the differences increase with the level of noise
- BM3D with default standard deviation of the noise (green) :
 - IBR better for a low level of noise

Performance :

Image denoising by means of the method **IBR** already gives satisfactory results for its entrance to the vast field of image processing

Current research :

- more freedom of shape in the creation of regions
- implementation of connections between similar regions

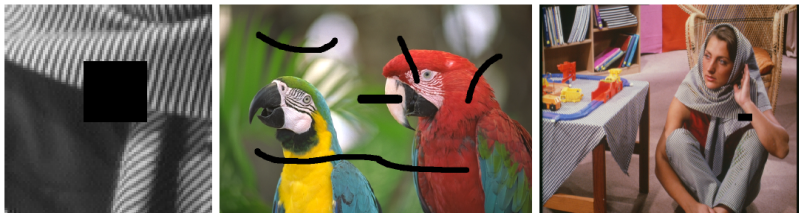
Others applications :

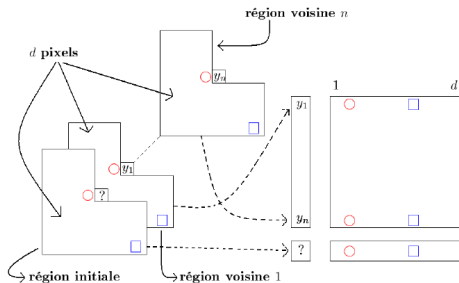
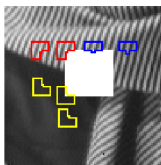
- use of the **rpart** partitioning for high-dimension data in regression
- application in chronological series

- **Objective** : reconstruct the missing parts of an image by means of the iterative bias reduction

Picture data base :

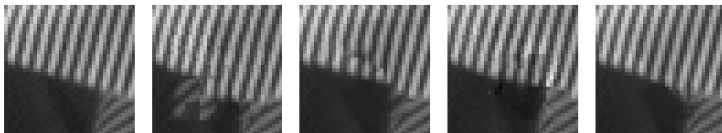
- black and white images and color images
- accent put on the structural reconstruction



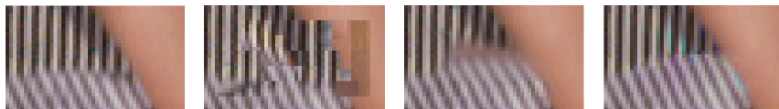


Process :

- ① pixels treated one by one, from extremities to the center
- ② definition of a region formed by the d available neighbors in a neighborhood of 4 pixels
- ③ **data base** : K nearest neighbors $\rightarrow n$ most similar regions



(a) Reference	(b)Criminisi <i>et al.</i>	(c)Wexler <i>et al.</i>	(d)Xu and Sun	(e)Proposed
PSNR :	18.84 dB	20.10 d	23.07 dB	25.83 dB
SSIM :	0.61	0.68	0.83	0.88



(a) Reference	(b)Criminisi <i>et al.</i>	(c)Wexler <i>et al.</i>	(d)Proposed
PSNR :	16.5 dB	21 dB	22 dB
SSIM :	0.46	0.70	0.78

- color images :
 - formed by three different images (Red, Green, Blue)
 - treatment separated by image

Conclusion :

- Good structural reconstruction
- No impression of blur
- **Current research** : use of the structural information of the image in the choice of the filling order
- **Others applications** : treatment of missing data, tested at the moment for chronological series



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