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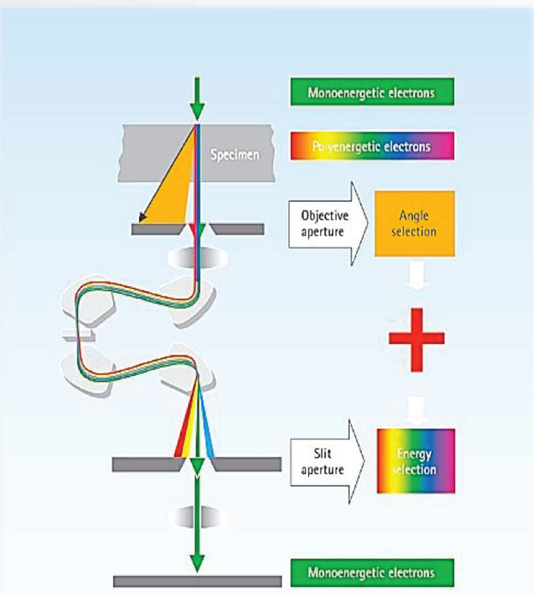
# Non Parametric Denoising Methods Based on Wavelets : Application to Electron Microscopy Images in Low Time Exposure

Soumia SID AHMED (1)
Zoubeida MESSALI (1) (2)

Science and Technology Faculty,
Bordj Bou Arreridj University

Electrical Engineering Laboratory (LGE),
M'sila University

## Objective




The Alignment step during the 3D reconstruction of the microscopy images (EM) is done in a more efficient manner if the used images are not affected by the noise, for the sake of getting a good 3D quality of these EM images which are naturally noisy because of the collision between the electrons beam and the specimen during the acquisition. We have applied four effective ways. Namely, Soft, the Hard as Wavelet-Thresholding methods, Bilateral Filter as a non-linear technique able to maintain the edges neatly, and the Bayesian approach in the wavelet domain, in which context modeling is used to estimate the parameter for each coefficient.

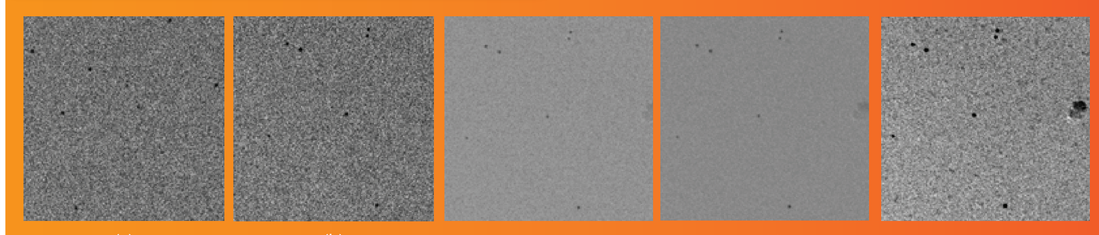
To assess our results, we've chosen the signal-to-noise-ratio SNR criterion beside the visual quality of the obtained images.

The upshot of these tests revealed the importance of the Bayesian Denoiser in attending the subjects we were asked about.

Matlab

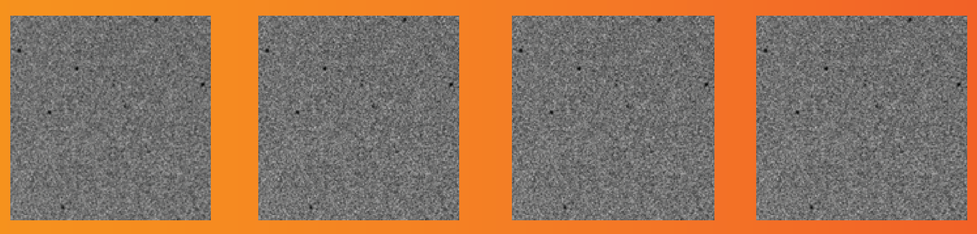
ImageJ 1.47

## Results



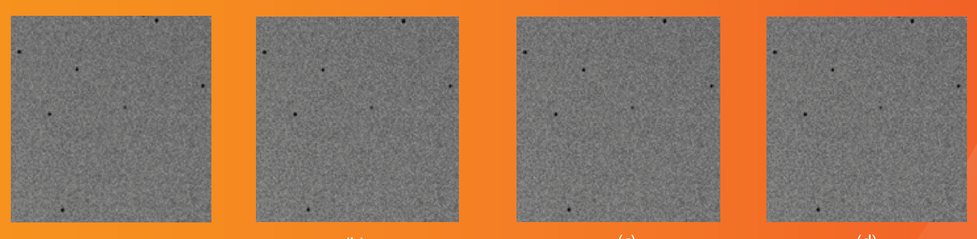
(a) (b) (c) (d) (e)

Fig1.The original images from zone1,(a) 0.1s-001,(b) 0.2s-001,(c) 0.5s-001,(d) 1s-001 and (e) 2s.



(a) (b) (c) (d)

Fig2.The Denoised image 0.1s-001 from zone1 after applying :(a) The bilateral Filtering, (b) The Bayesian Approaches, (c) Soft Thresholding,(d) hard Thresholding



(a) (b) (c) (d)

Fig2.The Denoised image 0.1s-001 from zone1 after applying :(a) The bilateral Filtering, (b) The Bayesian Approaches, (c) Soft Thresholding,(d) hard Thresholding

## Discussion

We first, show the first structure results where we denoised each image separately using the Soft and Hard Thresholding , Bilateral filtering and the Bayesian Approaches. The results are shown in Tab.1.Where we can see that the proposed method successfully enhance the SNR out compared to the SNR In of these images.

After applying the second structure, where we calculated the average image for different number of copies from the same zone. We can see from Tab.2 that the bilateral filtering gave the higher SNR out and each time we increase the number of copies, the SNR out is increased .

**TABLE 1**. The SNR in and SNR out Results of the first structure

| Zone1/ Images | S N R | Methods | S N R |
|---|---|---|---|
| 0.1s-001 | 17.1395 | Bayesian | 19.1895 |
| | | Bilateral Filtering | 20.7715 |
| | | Soft | 18.4397 |
| | | Hard | 18.4324 |
| 0.2s-001 | 20.2354 | Bayesian | 22.1332 |
| | | Bilateral Filtering | 22.4993 |
| | | Soft | 21.4752 |
| | | Hard | 21.4687 |
| 0.5s-001 | 24.0256 | Bayesian | 25.8649 |
| | | Bilateral Filtering | 25.0961 |
| | | Soft | 25.2006 |
| | | Hard | 25.1946 |
| 1s-001 | 26.7572 | Bayesian | 28.3607 |
| | | Bilateral Filtering | 27.2268 |
| | | Soft | 27.8743 |
| | | Hard | 27.8684 |
| 2s | 29.2794 | Bayesian | 30.7616 |
| | | Bilateral Filtering | 29.4420 |
| | | Soft | 30.3088 |
| | | Hard | 30.3024 |

**TABLE 2**. The SNR in and SNR out results of the second structure

| Images | Number of copies | SNR out | | | |
|---|---|---|---|---|---|
| | | Bayesian Approaches | Bilateral Filtering | Soft | Hard |
| 0.1s | 3 | 23,7583 | 25,2676 | 23,2447 | 23,2348 |
| | 6 | 26,6453 | 28,0739 | 26,1398 | 26,1297 |
| | 9 | 28,2426 | 29,6044 | 27,7485 | 27,7379 |
| | 12 | 29,3453 | 30,6455 | 28,8588 | 28,8485 |
| | 15 | 30,1496 | 31,4018 | 29,6777 | 29,6683 |
| | 18 | 30,8125 | 32,0129 | 30,3494 | 30,3391 |
| | 20 | 31,2103 | 32,3731 | 30,7411 | 30,7325 |
| 0.2s | 3 | 26,6256 | 26,9765 | 26,1161 | 26,1062 |
| | 6 | 29,3366 | 29,6684 | 28,8574 | 28,8481 |
| | 9 | 30,8405 | 31,1623 | 30,3947 | 30,3845 |
| 0.5s | 2 | 28,5501 | 27,8415 | 28,0556 | 28,0453 |
| | 3 | 30,0221 | 29,3583 | 29,56 | 29,5499 |
| | 4 | 30,9816 | 30,3649 | 30,5579 | 30,5491 |
| 1s | 2 | 30,8249 | 29,7785 | 30,3673 | 30,3585 |

**TABLE 3**. The Circularity before and after the Denoising

| Images | Circularity | Number of copies | Circularity | | | |
|---|---|---|---|---|---|---|
| | | | Bayesian Approaches | Bilateral Filtering | Soft | Hard |
| 0,1s | 0,702 | 3 | 0,752 | 0,786 | 0,774 | 0,782 |
| | | 6 | 0,785 | 0,784 | 0,783 | 0,776 |
| | | 9 | 0,763 | 0,772 | 0,785 | 0,75 |
| | | 12 | 0,784 | 0,754 | 0,78 | 0,729 |
| | | 15 | 0,757 | 0,776 | 0,784 | 0,775 |
| | | 18 | 0,757 | 0,771 | 0,782 | 0,769 |
| | | 20 | 0,784 | 0,769 | 0,777 | 0,77 |
| 0,2s | 0,742 | 3 | 0,76 | 0,779 | 0,783 | 0,77 |
| | | 6 | 0,761 | 0,783 | 0,78 | 0,773 |
| | | 9 | 0,764 | 0,769 | 0,772 | 0,747 |
| 0,5s | 0,781 | 2 | 0,873 | 0,873 | 0,782 | 0,781 |
| | | 3 | 0,809 | 0,869 | 0,771 | 0,783 |
| | | 4 | 0,785 | 0,782 | 0,773 | 0,722 |
| 1s | 0,761 | 2 | 0,786 | 0,774 | 0,695 | 0,687 |

we calculated the gold beads circularity for the sake of getting a good assessment of the used methods. We calculate this parameter by using ImageJ 1.47 according to the following equation : $\text{circularity} = 4.\pi \frac{\text{Air}}{(\text{perimetre})^2}$

## CONCLUSION AND FUTURE WORKS

In our work we have presented an efficient method in denoising the TEM images which is the Bayesian approaches, this method didn't give a higher SNR out than the bilateral filter but it result a better images quality (no changes in the circularity) than the other proposed methods especially for the multi copy structure, so by using multiple-noisy copies, we can reduce time exposure considerably. This is a very important result for the acquisition of biological samples

We recommend that the integration of wavelet de-noising technique in the pre-processing applied under the software designed for this aim, TomoJ will be given a greater role in enhancing the quality of reconstructed 3D volume.