Images enhancement using hybrid Median-Mean filters

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Abstract:

This paper presents new techniques for noise reduction depending on filters. The two proposed filters are to simulate and improve the effects of two kinds of smoothing filters: *Mean* and *Median* filters. These two filters are of amplitude and statistic kinds but they are vibrated between the linear and nonlinear kinds.The first proposed filter takes the average of mean and median filters for each pixel in the image as a new pixel in the filtered image. While the second filter takes the average of the W median intensity values in the mask (H×W) for each pixel in the image as a new pixel in the filtered image.Simulations show that the proposed filters work well in suppressing two different kinds of noise: *Poisson* and *Gaussian* from both images *grayscale* and *RGB* while preserving image details.

Keywords: Smoothing Filters, Median Filter, Mean Filter, Image Processing

1. *Introduction*:

In the last decades, the field of *Image Processing* (IP) became more and more attractive, sustained by the continuous advance of electrical and computer engineering. The increase of computer (processing) power allows considering successfully various applications. The typical image processing system consists of several different building blocks that perform distinctive tasks. Among them, the image enhancement stage is one of the most common encountered processing steps [2]. Image enhancement techniques are used to improve an image, where '*improve*' is sometimes defined objectively e.g., increase the Signal-to-Noise Ratio, and sometimes subjectively (e.g., make certain features easier to see by modifying the colors or intensities) [5]. The image enhancement techniques are based on either spatial or frequency domain techniques. The spatial domain refers to the image plane itself, and approaches in this category are based on a direct manipulation of pixels in an image. Frequency domain processing techniques are based on modifying the Fourier transform of an image. Also, one can deals with image enhancement techniques that are based either on point processing, which modified the intensity of a pixel independently of the nature of its neighbors or on mask processing. Masks are defined as small sub-images used in local processing to modify each pixel in the image to be enhanced.

The spatial domain refers to the aggregate of pixels composing an image, and spatial domain methods are procedures that operate directly on these pixels. The functions in the spatial domain may be expressed as [14]:

$$g(x,y)=T\left[f(x,y)\right] \quad \text{...(1)}$$

Where, $f(x, y)$ is the input image, $g(x, y)$ is the processed image, and T is an operator on f, defined over some neighborhood of (x, y).

The principal approach to defining a neighborhood about (x, y) is to use a square or rectangular mask area centered at (x, y), as Figure (1) shows. The center of the mask is moved from pixel to pixel starting, say, at the top left corner and applying the operator at each location (x, y) to yield g at that location. As Figure (1) shows, some of the pixels in a neighborhood may be missing, especially if the center pixel is on the border of the image. Notice that in the figure, the upper left and bottom right neighborhoods include "pixels" that are not part of the image. To process these neighborhoods they require to pad the borders of the image, usually with 0's. In other words, these functions process the border pixels by assuming that the image is surrounded by additional rows and columns of 0's. These rows and columns do not become part of the output image and are used only as parts of the neighborhoods of the actual pixels in the image [5, 9].

In this work, we found from experience (see Table (1)), that padding the additional rows and columns by the same border of the image gives results better than when padding it with 0's or 1's, so the first one was used.

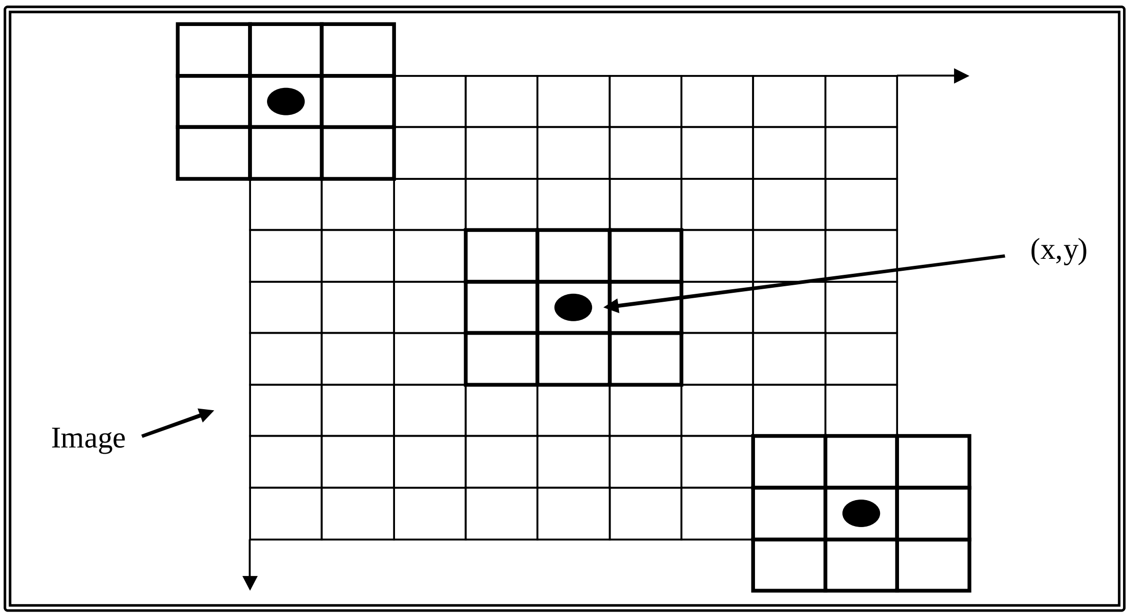

Figure (1): A 3x3 Mask about a point (x, y) in an image.

Table (1): Comparative Results in PSNR (dB) of Filtering Different 8-bits Grayscale Images Corrupted by Poisson Noise with Multi Different Way Fill Border.

Padding type		Filter type		
		MED	AVG	Proposed 2
Fill added border with 0's	gray 2 26.71	31.89	25.74	32.38
	gray 3 27.24	31.68	30.73	32.16
Fill added border with 1's	gray 2 26.71	31.9	25.76	32.38
	gray 3 27.24	31.68	30.75	32.16
Fill added border with same original image border	gray 2 26.71	33.17	27.82	33.15
	gray 3 27.24	31.77	32.01	32.24

2. Smoothing Filters:

Smoothing filters are used for noise reduction. Noise reduction is also called *low pass filter* since it leaves the low frequency components unchanged [9, 11]. The proposed filters techniques in the work are to simulate and improve the effects of two kinds of smoothing filters. These two filters are of amplitude and statistic kinds but they are vibrated between the linear and nonlinear kinds. These two filters as stated below:

a. Average Filter (AVG)

The *Average Filter* also called *Mean Filter* is a linear filter. It takes the average of intensity values in an (H×W) region of each pixel (usually H=W) as the new pixel value for the image (M × N), that is:

$$AVG(i, j) = mean\{ u(r, c) ,\ i \le r \le i+H-1 \text{ and } j \le c \le j+W-1 \} \quad \textbf{. . . (2)}$$
$$1 \le i \le M ,\ 1 \le j \le N$$

Where, u : the image after adding the additional rows and columns.
M, N : number of rows and columns for original image respectively .
The normalization factor (H×W) preserves the range of values of the original image. If we replace each pixel in the noisy image by the average of its local neighbors within an (H×W) mask then the image will be smoothed because averaging elements will reduce the noise mean towards zero. AVG is a simple filter for all the types of noises but it is more effective in removing additive noise [3, 15].

b. Median Filter (MED)

Nonlinear filters are widely used in image processing for reducing noise without blurring or distorting edges [8]. *Median filters* were among the first nonlinear filters used for this purpose [10]. It is the most common used kind of order-statistic filter where the pixel valued in the mask will be ranked then take the n-order value for example the minimum, maximum or commonly the middle (median) value, that is:

$$MED(i, j) = median_1\{ u(r, c) ,\ i \le r \le i+H-1 \text{ and } j \le c \le j+W-1 \} \quad \textbf{. . . (3)}$$
$$1 \le i \le M ,\ 1 \le j \le N$$

Where, $median_1$ return to the middle pixel in the mask (H×W).

The filter preserves monotonic image features that fill more than half the area of the transform window. MEDs are especially good at removing measurement noise from images. The particular nonlinearity of the median filter permits it to smooth an image without the degree of blurring that a linear filter with similar smoothing characteristics can introduce. It is very effective in removing impulse noise while preserving image detail with one disadvantage which is the computational complexity [1, 3, 5, 7, 16].

3. Proposed filters:

In this work two proposed filters are to simulate and improve the effects of two different kinds of smoothing filters: *mean* and *median* filters as shown below:

- **First proposed filter (Proposed$_1$)**

This filter consists of replacing the input pixel by the average of the median and mean of the pixels in the neighborhood mask (H×W), that is:

$$Proposed_1(i, j) = round\{ \{MED(i, j) + AVG(i, j)\} / 2 \} \quad \textbf{. . . (4)}$$

Where, $1 \le i \le M, 1 \le j \le N$

This needs to apply the mask (H×W) of the median and the mean filters to pick the average of the two results as the new pixel in the filtering image.

- **Second proposed filter ($Proposed_2$)**

This filter consists of replacing the input pixel by average of the W middle pixels in the neighborhood mask (H×W), that is:

$$Proposed_2(i, j) = mean\{ median_W\{u(r, c) , i \le r \le i+H-1 \text{ and } j \le c \le j+W-1 \} \} \quad \ldots (5)$$
$$1 \le i \le M , 1 \le j \le N$$

Where, $median_W$ return the W middle pixels in the mask (H×W).

This needs to sort the pixels in the mask (H×W) in an ascending order and to pick the average of the W middle pixels as the new pixel in the filtering image.

4. Experimental Results:

The proposed filters were tested using various types of images: *8-bit grayscale* and *24-bit RGB* images degraded by two different types of noise: *Poisson* and *Gaussian*.

The performances of the proposed filters were compared with the median (MED) filter and the average (AVG) filter. There are many performance measures available and *Peak Signal to Noise Ratio (PSNR)* which was calculated by equal (7) [13] has been adopted as the objective criterion to evaluate the performance of the filters in our experiment. In all tests, a filtering mask of (3x3) size slides from pixel to pixel in rater scanning fashion.

$$MSE = \frac{1}{M \times N} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} (A(i,j) - B(i,j))^2 \quad \ldots (6)$$

The PSNR in decibels (dB) is computed by using:

$$PSNR = 20 \cdot \log_{10} \left(\frac{Max_A}{\sqrt{MSE}} \right) \quad \ldots (7)$$

Here, A and B the original and filtering images (M×N) respectively. Max_A is the maximum pixel value of the image *A*. *MSE* is the mean squared error.

For color images with three RGB values per pixel, we applied each filter on the matrix of each color (Red, Green, Blue) separately then combined the three resulting 8-bit grayscale images to get the filtered 24-bit RGB image and the definition of PSNR is the same except the MSE is the sum over all squared value differences divided by image size and three [13].

To assess the effectiveness of the proposed filters in processing different images, we tested the filters more than twenty times in each test different image was used, Tables (1) and (2) present the comparison results for two types of images *grayscale* and *RGB* [5] degraded by *Poisson* and *Gaussian* noises [4, 6, 12]. It can be noticed that the better performance of the proposed filters from these tables that PSNR values of our filters are bigger than of the other filtering methods under study. Figure (2) shows the results of one of these test.

Many tests are achieved to illustrate the impact of the size of the filter mask and number of filter repetition on the performance of filters. The results show that sometimes we need to repeat the filter several times according to the user needed to obtain an acceptable performance. On the other hand, the size of the filter mask is usually taken to be an intermediate value to balance the tradeoff between noise smoothing and image smoothing. These tests are shown in Figures (3) and (4).

Table (2): Comparative Results in PSNR (dB) of Filtering Different 8-bits Grayscale Images Corrupted by Poisson and Gaussian Noise.

Noise type	Image	Filter type			
		MED	AVG	Proposed1	Proposed2
Poisson	gray1 26.169	29.075	27.349	28.715	29.409
	gray2 26.679	33.053	27.799	30.926	33.062
	gray3 27.251	31.79	31.999	32.293	32.249
	gray4 26.259	32.117	33.088	32.932	33.125
Gaussian	gray1 20.161	25.397	25.745	25.821	25.947
	gray2 20.132	26.979	26.032	27.069	27.429
	gray3 20.082	26.798	28.176	27.831	28.158
	gray4 20.030	27.171	28.684	28.27	28.691

Table (3): Comparative Results in PSNR (dB) of Filtering Different RGB Images Corrupted by Poisson and Gaussian Noises.

Noise type	Image	Filter type			
		MED	AVG	Proposed1	Proposed2
Poisson	RGB1 27.629	32.026	32.23	32.571	32.529
	RGB2 26.969	28.857	27.881	28.801	29.116
Gaussian	RGB1 20.612	27.065	28.341	28.133	28.245
	RGB2 20.434	25.369	25.868	25.861	26.001

Original image

Noise image (by Poisson)

PSNR= 27.251 dB

Median filter result image

PSNR=31.79 dB

Mean filter result image

PSNR=31.99 dB

Proposed 1 filter result image

PSNR = 32.293 dB

Proposed 2 filter result image

PSNR = 32.249 dB

Figure (2): Image results of filters simulation for the image Lena corrupted by Poisson noise.

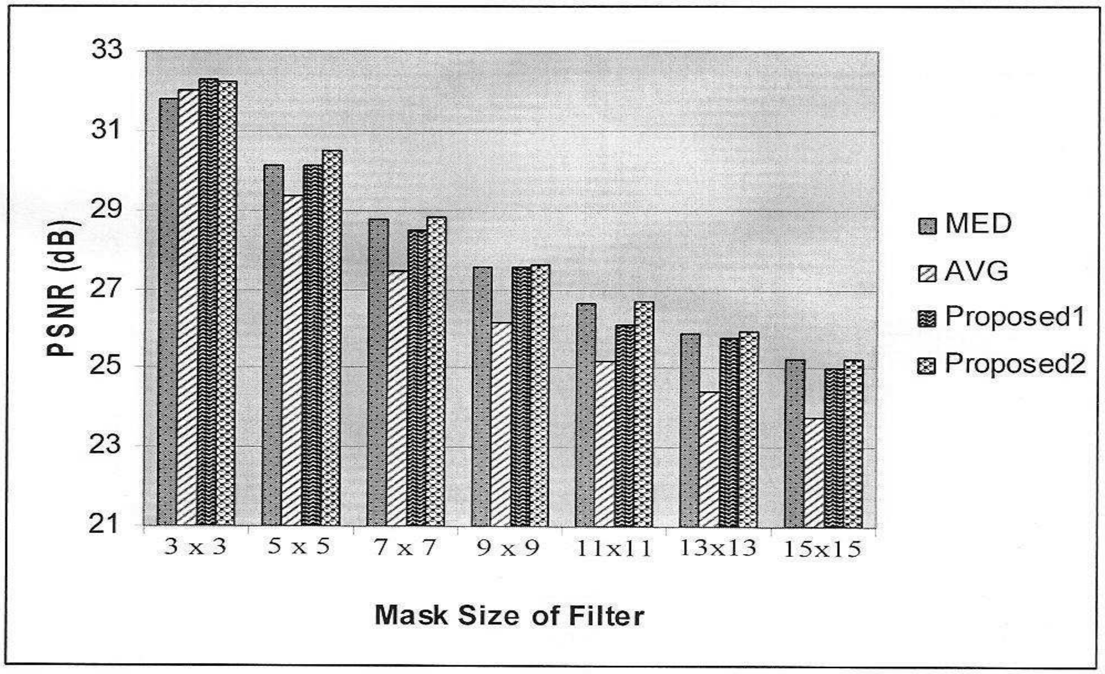

Figure (3): Effect the Mask Size of Filter on Filters Performance.

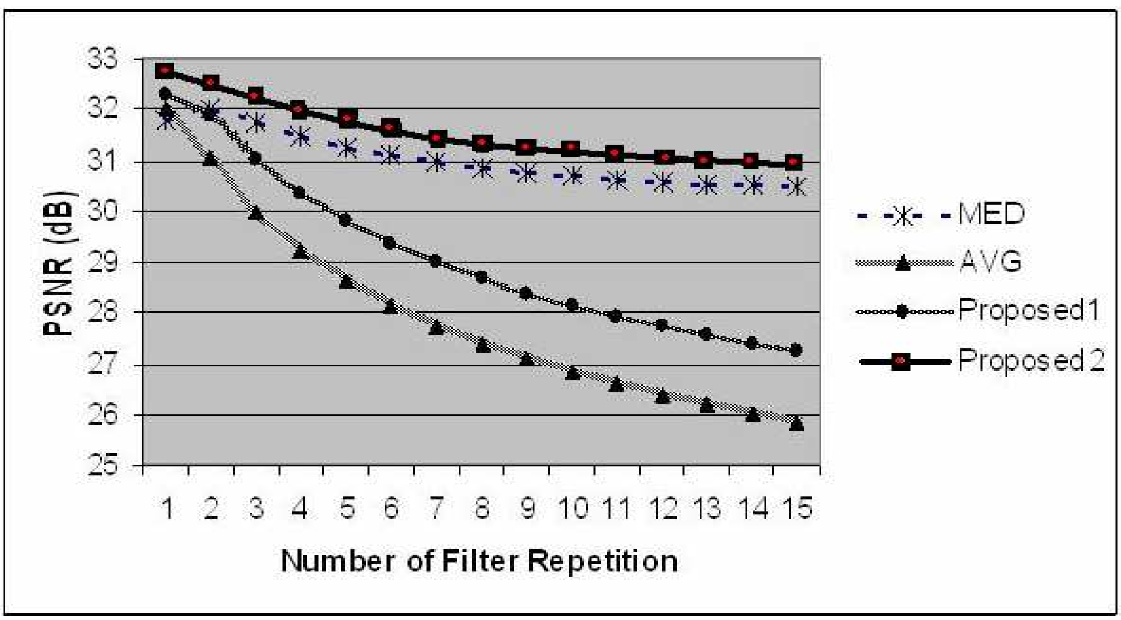

Figure (4): Effect the Number of Filter Repetition on Filters Performance.

5.*Conclusions* :

Based on the presented results we concluded the followings:

a. The proposed filters present a quite stable performance over a wide variety of different types of images and noises.
b. Padding the additional rows and columns with the same border of the original image gives a better performance than when padding it with 1's and the latter gives a better performance than when padding it with 0's.
c. Sometime we need to reiterate applying filters many times to obtain acceptable results (see Figure (4) the MF gives best performance in iteration two).
d. The tradeoffs between noise reduction and the sharpness of the image when the mask size is increased.
e. The mean of AVG and MED filters gives a better performance than when apply each filter alone to most test images.

6. *References* :

1. A. Kokaram, ***"Pixel and Spatial Operations"***, 1E8: Introduction to Engineering, Introduction to Image and Video Processing, 2004.

2. C. Vertan, and V. Buzuloiu, ***"Reduced Computation Genetic Algorithm for Noise Removal"***, Politehnica University, Bucharest, Romania, 2000.

3. E. Petrakis, ***"Computer Vision"***, Electronic and Computer Engineering Department, Technical University of CRETE, China, 2001, website: www.ced.tuc/~petrakis/courses/computervision/syllbus.htm

4. G. Baker, ***"Image Noise"***, website: www.cs.nu.oz.au/~gavinb/download.php?file=noise.pdf

5. H. Demuth, and M. Beale, ***"Image Processing Toolbox"***, User's Guide, version 4, for use with MATLAB, Massachusetts: The Math Works Inc., 1998.

6. H. Gomez-Moreno, S. Maldonado-Bascon, F. Lopez-Ferreras, M. Utrillamanso, and P. Gil-Jimenez, ***"A Modified Median Filter for the Removal of Impulse Noise Based on the Support Vector Machines"***, 2001.

7. H. Guray, R. Peters, and B. Dawant, ***"Topological Median Filters"***, IEEE Transactions on Image Processing, vol. 10, no. 12, 2001.

8. I. Pitas and A. Venetsanopoulos, ***"Edge Detectors Based on Nonlinear Filters"***, IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 8, no. 4, pp. 538-550, 1986.

9. J. Gomes, L. Velho, ***"Image Processing for Computer Graphics"***, Springer-Verlag, New York, Inc., 1997.

10. J. Tukey, ***"Exploratory Data Analysis"***, Addison-Wesley, Reading, Massachusetts, 1971.

11. J. Tukey, "***Nonlinear (nonsuperposable) Methods for Smoothing Data"***, Cong. Rec. EASCOM, pp. 673, 1974.

12. M. Bjorkman, and D. Kragic, ***"Image Enhancement by Filtering"***, website: www.nada.kth.se/kurser/kth/2D1421/aktuellt.html

13. M. Rabbani, and P. Jones, ***"Digital Image Compression Techniques"***, vol. TTZ, SPIE Optical Engineering Press, Bellvue, Washington, 1991.

14. R. Gonzales, and R. Woods, ***"Digital Image Processing"***, 1st Edition, Addison Wesley PCI, 1992.

15. S. Shah, ***"Introduction to Digital Image Processing"***, 2005, website: www.cs.uh.edu/~shah/teaching .

16. Z. Liu, ***"EL512 Image Processing"***, Course introduction basic concepts and techniques in digital image processing, 2004, website: www.vision.poly.edu:8080/~zhul/EL512 .

تحسين الصور باستخدام
مرشحات هجينة وسطي – معدل

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المستخلص :

يعرض هذا البحث تقنيات جديدة لتقليل الضوضاء بالاعتماد على المرشحات. المرشحان المقترحان يحاكيان ويحسنان نتائج نوعين من مرشحات التنعيم هما: مرشح المعدل ومرشح الوسيط. هذان المرشحان هما من أنواع مختلفة الأول خطي واتساعي بينما الثاني غير خطي وإحصائي. المرشح المقترح الأول يقوم بحساب معدل ناتجي المرشحين الوسيط والمعدل لكل نقطة في الصورة لتمثيل قيمة النقطة الجديدة في الصورة المحسنة. أما المرشح الثاني فيقوم بحساب معدل W قيمة وسطى من قيم الشدة في النافذة (H×W) لكل نقطة في الصورة لتمثيل القيمة الجديدة في الصورة المحسنة.

محاكاة المرشحات أظهرت أن المرشحين المقترحين يعملان بصورة جيدة في اخفاء نوعين مختلفين من الضوضاء هما بواسون وكاوس ولنوعين من الصور الرمادية و الملونة RGB مع الحفاظ على تفاصيل الصورة.

الكلمات المفاتيح: مرشحات التنعيم، مرشح الوسيط، مرشح المعدل، معالجة الصور