De-Noising of Corrupted Fluoroscopy Images Based on a New Multi-Line Algorithm

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Abstract

   Fluoroscopic images are a field of medical images that depends on the quality of image for correct diagnosis; the main trouble is the de-nosing and how to keep the poise between degradation of noisy image, from one side, and edge and fine details preservation, from the other side, especially when fluoroscopic images contain black and white type noise with high density. The previous filters could usually handle low/medium black and white type noise densities, that expense edge, =fine details preservation and fail with high density of noise that corrupts the images. Therefore, this paper proposed a new Multi-Line algorithm that deals with high-corrupted image with high density of black and white type noise. The experiments achieved images with a high quality and effectively preserved edge and fine details against black and white type noise densities depending on Peak Signal to Noise Ratio (PSNR), Mean Squared Error (MSE), and Image Enhancement Factor (IEF) measures.

Keywords: black and white type noise, de-noising high densities, fluoroscopy images, Multi-Line algorithm, corrupted images.

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ازالة الضوضاء عالية الكثافة للصور الفلورية الطبية باستخدام خوارزمية مقترحة متعددة الاسطر

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الخلاصة

   تُعد الصور الفلورية مجالًا من الصور الطبية التي تعتمد على جودة الصورة للتشخيص الصحيح ، والمشكلة الرئيسية هي ازالة الضوضاء ذات الكثافة العالية (noise with high density) وكيفية الحفاظ على حواف التفاصيل للصورة من جانب والحفاظ على التفاصيل الدقيقة من الجانب الآخر ، خصوصًا عندما تحتوي الصور الفلورية على ضوضاء من النوع الأسود والأبيض بكثافة عالية. يمكن للمرشحات السابقة أن تتعامل عادةً مع كثافة ضوضاء من النوع الأسود والأبيض المنخفضة / المتوسطة التي تعمل على الحفاظ على حافة التفاصيل والحفاظ على التفاصيل الدقيقة وتفشل مع وجود كثافة عالية من الضوضاء التي تتلف

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الصور. لذلك اقترح هذا البحث خوارزمية جديدة متعددة الأسطر تتعامل مع صور متأثرة بكثافات عالية من

الضوضاء بالأبيض والأسود (Black & white noise) ، وقد أجريت التجارب على صور متأثرة بكثافات

عالية من الضوضاء وحافظت على حواف التفاصيل مع الحفاظ على التفاصيل الدقيقة ضد كثافات العالية

للضوضاء بالأبيض والأسود اعتمادًا فعالًا على مقاييس PSNR و MSE و IEF. لجودة الصور.

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I. INTODUCTION

Recently, the diagnosis with digital image processing in the medical fields became very important because the correct diagnosis relies on the features that are extracted as well as image quality; with any degradation in image acquisition will lead to misdiagnosis [1]. One of the most degradation types in image processing fields is noise that corrupts the image quality. Corrupted image via impulse noise is a regular phenomenon that appears in the acquisition and transmission of a digital image and signal processing [2]. As known, noise is unwanted information that contaminates a captured image that appears from a variety of sources, as a random variation of brightness, which is converting an optical image to an electronic one with continuous signal. Then quantization and sampling to a digital image are performed, leading to degrading the quality of images [2].

Multi-stage median filter (MSMF) depends on multi-levels, firstly applying a window size of 5*5 and then calculating the median values for the vertical, horizontal, diagonal1, and diagonal2 axes along with the remaining pixels and This filter of the 5 median values results in the improvement of edge and preservation of fine details [3].

Improving the Effectiveness of the Median Filter (IEMF) depends on two levels of effectiveness. The first level involves applying a 3*3 size window, arranging the values in ascending order, removing the first and commuting with the next values, and then removing the last and commuting with previous values. This procedure is repeated in the second level and, therefore, this algorithm is able to remove 30% of density [4].

Due to the mentioned non-linear filters, the early AMF could achieve good edge preservation but did not work precisely with high density of noise and AMF depending on replacement of a value of ordered pixel that uses one level of chosen middle value that may caused a replacement of noisy pixel [5]. Another example is the DBMF according to the robust replacement rule that ensures high removal of noisy pixels, but at the expense of fine details preservation [6].

For noise removal, one category of non-linear filters was previously proposed, represented by formal median filter and variants, e.g. Adaptive Median Filter by increase the size of window caused to blur effect [7]. Generalized of Mean Filter [8], Decision Based Algorithm caused streak effect [9], Modified Decision Based Un-Symmetric Trimmed Median Filter [10], Noise Adaptive of Fuzzy Switch Median Filter [11], Efficient and Fast Median Filter [12], Adaptive Window of Multi-stages Median Filter [13], Adaptive of Weighted Mean Filter [14]. Hybrid Median Filter (HMF) functions by calculating the median of three values, namely vertical axis, horizontal axis and any other diagonal, by using a slide window. It is used to enhance the contrast and fine edge as well as to suppress noise and locate the features, but it affects the quality of image [15].

Those previous median filters use a slide window within which all pixels are arranged in an ascending order, which are then replaced with their median values leading to the loss of edge and details of the captured image.

Moreover, the standard median filters blur the image when using a large size of window, and they do not perform well in high percentages of image corruption with black and white noise in the matter and, hence, they do not reach sufficient edge preservation [3].

II. BLACK and WHITE NOISE MODEL

In acquisition or transmission stage, there are many fluctuations caused via natural phenomena that are adding some random values to each pixel. Those new values are formatted as a noise with undesired intensities called the black and white noise. Noise appears in images through the analog-to-digital conversion from a variance of sources, which is converting optical image to signals, followed by sampling and quantization processes [6]. Therefore, in medical images, black and white noise is defective and distorts the diagnosis of disease that depends on the quality of images [16]. In typical digital images of 8-bit, it easy to recognize this type of noise because it contains 256 intensities, with a minimal value (0) for pepper type noise and a maximal value (255) for salt type noise [16].
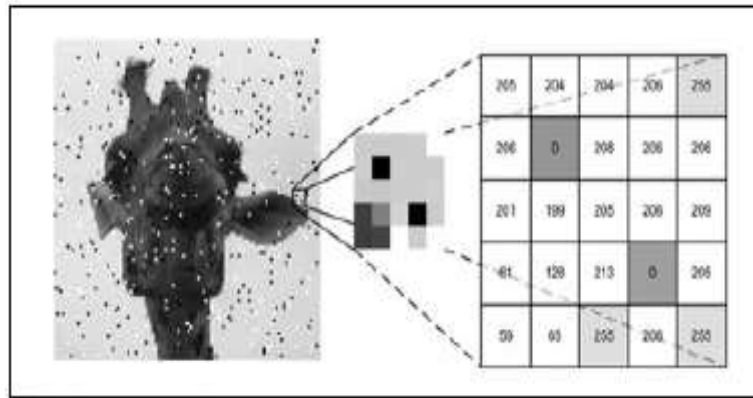
Figure 1- Image corrupted with black and white noise

Probability Intensity Function (PIF) of black and white noise in images could be expressed as follows:

$$PIF[g(i,j)] = \begin{cases} p/2 & \text{for } g(i,j) = 0 \\ p/2 & \text{for } g(i,j) = 255 \\ \text{otherwise} & g(i,j) = f(i,j). \end{cases} \tag{1}$$

where f(i,j) is the original gray-level value, p is the probability of degradation function, and g(i,j) is the gray-level value of the corrupted image.

III. IMAGE DE-NOISING ALGORITHMS

According to the diversity of types of noise, there are several filter algorithms with different requirements , which are classified into [1]:

1-   Frequency Domain Filters

They transform an image from a spatial domain to a frequency domain using transforms such as Fourier, cosine, and wavelet. Multiplied by filter function that results in either smoothen or sharpen the image according to attenuating the frequencies then transformed back to spatial domain [17].

2-   Spatial Domain Filters

They involve a window size, that convolutes over all image's pixels, and apply mathematical operations such as point and neighbour operations. They result in degraded and enhanced images [17], as illustrated in Figure-2.
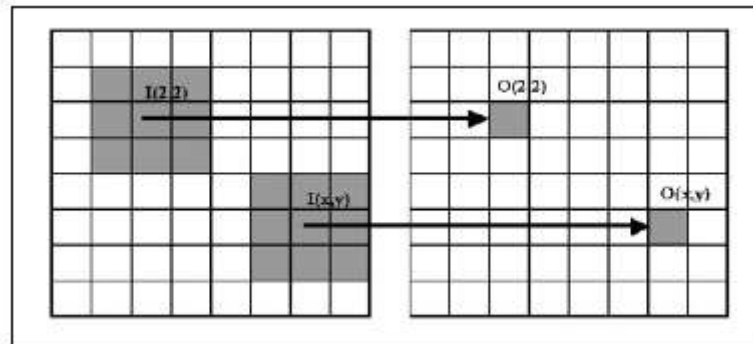

Figure 2- Spatial Domain Filter's principle

Spatial filters are divided into non-linear and linear filters.

Linear spatial filters involve the modification of an image, which replaces the value of each pixel with a linear function from its neighbours, such as AVGF, WMF and others [13].

Nonlinear spatial filters do not follow the linearity properties, but just perform operations depending on the model of filter, such as SMF and HMF [14].

Moreover, both non-linear and linear spatial filters are function in image processing, but the difference is that nonlinear filters are considered powerful tools especially for white and black type noise. They could achieve noise removal while preserving edge and details. However, linear filters are easy to use and fast enough, but lead to losing the details of an image [18, 19].

IV.THE PROPOSED MULTI-LINE FILTER ALGORITHM

Numerousness of non-linear and linear filters lead to difficulties in selecting a suitable filter; however, the density of noise, type of noise, and image data are comparative with the resultant quality of image, depending on PSNR and MSE [14].

Previous related research examined the efficiency and performance of filters. In our study, we focused on high density of black and white type noise that should be removed from fluoroscopic images. The following algorithm describes how the new proposed algorithm works:

Step 1: Apply on a 2-dimensional image and a two dimensional window (denoted by 5×5) which are selected and centred through the processed pixel g (i, j) in the high-density image.

Step 2: Divide the selected window into 5 vectors, each representing a horizontal line.

Step 3Sort the pixel's value in the selected vector in an ascending order and find the median pixel value.

Step 4: Repeat step 3 to each vector in Figure- 3, and put the result in a new vector (ML1, ML2, ML3, ML4, ML5), then find the median to the new selected vector as well.

Step 5: Replace the result with the centre pixel in the windows 5*5 in an image.

Step 6: Keep repeating steps 1 to 5 till the processing is completed for the entire chosen image.

- **Pseudo Code of the Proposed Algorithm**

Program Multi-Line Median Filter

For every pixel in the image **do**

       Select size window (mask) 5*5

       Divided the selected size window into five vectors

       Each vector represents a horizontal line

       For the selected 5*5 Mask **do**

              Sort values in each horizontal line

              Pick the middle value in the sorted horizontal line

       End

       Place the five resulted middle values in buffer vector

       Pick the middle value in the sorted buffer vector

       Replace the centred pixel value with a Multi-Line Median one

End

The resultant multi-line filter algorithm according to the MSE and PSNR is considered to cause substantial removal of black and white type noise with high density and keep good edge and fine detail preservation.
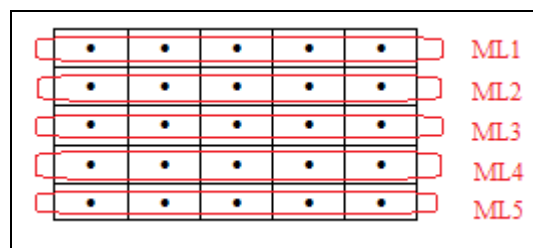

Figure 3-Computation of Multi-line Median Filter algorithm

New Vector=Median (MLi), i =1,2,3,4,5

Result = Multi-Line Median (ML11,ML2,ML3,ML4,ML5)

V. SIMULATED RESULTS AND ANALYSIS

The newly proposed multi-line filter algorithm was examined over 8-bit gray-scale and colour images of different sizes that are corrupted with black and white type noise with different densities (from 10% to 80%). It was compared with different types of previous filters such as SMF, HMF, DBMF, IEMF, MSMF, and AWMF. Then, different measures were used, such as PSNR , which indicates signal to noise and is a very good measure for noise reduction quality. On the other hand, it indicates the reconstruction of a higher quality of an image. In addition, MSE is a measure that indicates mean square error, which is a second measure that finds the difference in the intensity

between the input-image and output-image. IEF is a measure that indicates image enhancement factor and the quality of an image depending on edge preservation.
where

$$PSNR = 10 \log 10 \ (255^2 / \ MSE) \tag{2}$$

where

$$MSE = 1 / MN \sum \sum (Xi, K - X'j, K) \tag{3}$$

where Xj,K is the input-image and X'j,K is the output-image.
where

$$IEF = (\sum noisy \ (i,j) - f(i,j)) \ / (\sum f'(i,j) - f(i,j)) \tag{4}$$

The following tables represent the results of the experimentally tested fluoroscopy images, where the proposed filter is denoted as **PF.**

Table 1- PSNR of fluoroscopy image

Noise%	SMF	HMF	DBMF	IEMF	MSMF	AWMF	PF
10	35.66	42.44	44.56	45.66	47.67	46.89	48.32
20	34.88	43.45	42.77	44.17	47.74	45.75	47.89
30	33.45	42.78	40.22	43.88	46.66	44.34	46.98
40	30.67	41.77	39.56	42.21	45.31	42.56	45.78
50	29.11	38.55	38.21	41.46	42.44	41.56	43.87
60	27.89	37.44	37.89	40.44	41.67	40.23	41.99
70	26.90	31.56	34.67	37.93	36.58	35.98	38.56
80	22.91	27.56	29.72	30.74	32.11	33.85	34.12

Table 2- MSE of fluoroscopy image.

Noise%	SMF	HMF	DBMF	IEMF	MSMF	AWMF	PF
10	15.66	14.58	12.45	11.04	10.58	10.11	8.45
20	20.45	18.47	16.58	15.14	13.45	12.14	11.36
30	41.78	38.66	21.47	18.35	16.47	15.75	13.49
40	45.25	51.44	47.69	36.47	31.9	30.78	25.45
50	67.45	70.45	55.78	42.47	35.78	36.88	31.58
60	89.32	68.45	61.54	55.47	47.68	46.21	43.87
70	113.12	102.13	87.12	71.87	64.85	63.75	61.87
80	126.45	98.47	92.47	87.78	79.47	78.65	72.64

Table 3- IEF of fluoroscopy image.

Noise%	SMF	HMF	DBMF	IEMF	MSMF	AWMF	PF
10	7.56	8.63	9.14	11.32	21.23	22.12	26.42
20	7.11	8.11	8.68	10.21	19.25	18.63	21.56
30	6.56	7.32	7.86	9.11	17.54	17.44	19.36
40	6.12	6.88	7.36	8.23	16.25	15.87	18.25
50	5.45	6.11	6.78	7.45	14.32	14.44	17.87
60	4.98	5.23	5.94	6.32	11.32	12.36	14.65
70	3.81	4.54	5.46	5.94	8.15	9.21	11.33
80	2.74	3.78	4.58	5.14	7.68	7.87	9.21

Tables-(1, 2, 3) involve PSNR, MSE, and IEF measures, respectively, of different noise ratio and comparative results of applying different previous filters over fluoroscopy image
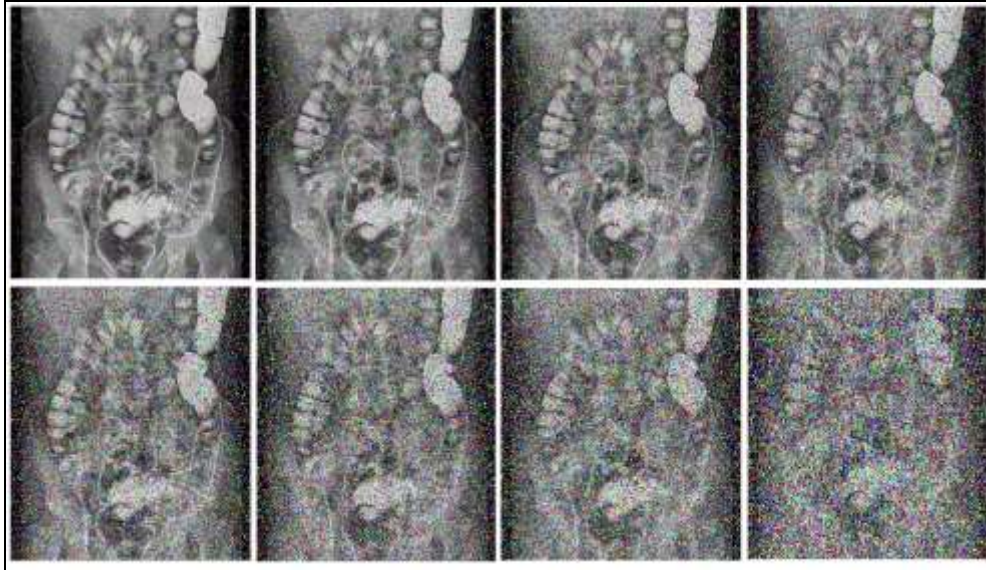
Figure 4- Noisy fluoroscopy image with different percentages (10% up to 80%).

Figure-4 illustrate noisy fluoroscopy images from 10% up to 80%, and from previous table notice when ratio of noise getting high then will corrupted the image that expense the edge and fine detail preservation
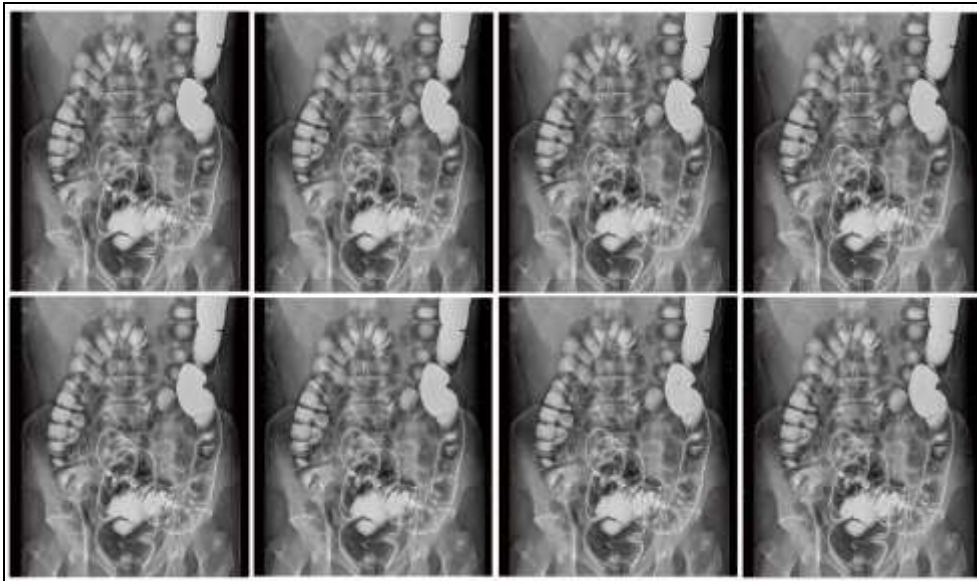

Figure 5- Comparative results of applying Multi-Line Algorithm Filter on previous noisy fluoroscopy image (10% up to 80%)

Figure-5 illustrates how Multi-Line algorithm works effectively against black & white type noise on corrupted image with high density, with good edge and fine detail preservation.

VI. CONCLUSIONS

During this approach, a new Multi-Line filter algorithm was proposed for de-noising images corrupted by black and white type noise. Black and white type noise with high densities of 10% up to 80% was added to the input image and then the noisy pixels were effectively removed by the proposed algorithm. Then the proposed algorithm was tested according to PSNR, MSE, and IEF measures, as well as in comparison with other previous filter algorithms. The simulation results showed that the proposed algorithm has a very satisfactory de-noising efficiency, with keeping good levels of edge and fine detail preservation in corrupted images with high densities of black and white type noise.

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