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Full Length Research Paper

De-noising of medical images by using some filters

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Removal of noise from the medical images was done using different filters. MATLAB programming software was used as implementation codes to investigate this fact. Selected images were split into two different formats: JPG and TIF. Some images have noise by different types of noise. Different noises have been considered in this research, and they are: Poisson, speckle and Gaussian. De-noising techniques (using MATLAB programming) were used to restore the mentioned noises on the images. Different types of filters were used to remove the noises such as Average filter, Gaussian filter, Log filter, Median filter, and Wiener filter. At the final stage, the results of the mentioned filters were compared to get the best and suitable filter for the images of the cell and breast. Image quality parameters: MSE, SNR, and PSNR were considered as the main parameters for the comparison. The results verified that the Gaussian filter is a suitable filter to remove the noise in the medical images.

Key words: Medical images, noises, filter, de-noise.

INTRODUCTION

Digital image, “an image consisting of data (specifically a set of elements)”, is defined on an *n*-dimensional regular grid that has the potential for display. These elements are referred to as pixels. The pixels in different images may represent a variety of information, such as temperature, pressure, velocity, terrain height, or tissue density. The regular grid is frequently over a two-dimensional space but can be three-dimensional, and even four-dimensional if sampling over time is also included. The applications of Digital image restoration (using filters to handle the noise situation) are widespread in various areas. These areas include medical imaging, space imaging, weather imaging, image compression, electronic and industry. Medical images are corrupted by different types of noises; it is very important to obtain precise images to facilitate accurate observations for the given application. Low image quality is an obstacle for effective feature extraction, analysis, recognition and quantitative measurements. Therefore, there is a fundamental need of noise reduction from medical images (Nobi and Yousuf, 2010).

Several medical images are noisy and blurred. For example, an Ultrasound image, Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Digital Mammography, Digital Microscope, and Digital X-ray are among the most common tools for diagnosis. These images are often affected by random noise arising in the image acquisition process. These images are also corrupted with noise, for example, ultrasonic images are assumed to contain speckle noise and CT images are supposed to be corrupted by Poisson and Gaussian distributed random noise and found in standard X-ray films; however, noise in MR images obeys a Rician distribution. Corruption of noisy images with blur makes it poor for visual analysis (Khare and Tiwary, 2005). Image de-noising is one of the most significant tasks in image processing, analysis and image processing applications. Medical imaging is one of the emerging application areas where the image de-noising plays a vital role. In this occasion, image de-noising is an essential pre-requisite, especially in x-ray, which is an important and most common modality in medical imaging (Ali et al., 2010).

Image de-noising is a procedure in digital image processing aiming at the removal of noise. Noise removal is essential in medical imaging applications in order to enhance and recover fine details that may be hidden in

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the data (Satheesh and Prasad, 2011). X-rays are the oldest and the most frequently used form of medical imaging. X-ray is a painless medical test, which helps physicians diagnose and treat medical conditions. This medical test involves exposing a part of the body to a small dose of ionizing radiation with the objective of producing pictures for the inside of the body (Mahmoud and Marshall, 2008). Mammography is the most effective method for the early detection of breast diseases. However, the typical diagnostic signs such as micro calcifications and masses are difficult to detect because mammograms are of low-contrast and noisy. Breast cancer is one of the leading causes of women mortality in the world. The primary goal of mammography screening is to detect small, non-palpable cancers in its early stage. But mammograms are difficult to interpret as the pathological changes of the breast are subtle and their visibility is poor in low contrast and noisy mammograms (Krishnamoorthy et al., 2010). In fact, it is a challenge to improve the visual quality of mammograms by image processing for helping in the early detection of breast cancer and applying (ALARA) principle. Thus, image de-noising is one of the fundamental tasks required by medical imaging analysis. In this work, we investigated some filters for medical imaging applications. In the past, median filters and other nonlinear filters, as well as Wiener filters and other optimization filters, have been used as restoration methods for images with noise. A median filter is a filter effective for both preserving the edges that cannot be preserved in a conventional linear filter and removing the impulse noise, but it has problems. Firstly, there is the problem of new blurriness in the image resulting from processing that does not take edges and non-edges in the image into consideration. Secondly, there is the problem of it not working effectively on Gaussian noise. The Wiener filter is a filter that is more effective at preserving image edges and higher frequency areas than a conventional linear filter is, and it works efficiently when the noise is Gaussian noise or other forms of white noise (Wang et al., 2008).

IMAGE ENHANCEMENT

Image enhancement refers to the process of noise reduction or to the sharpening of images in order to enhance the quality of the image. Although the technique of image enhancement is well developed, we limit ourselves here to techniques that are based on the idea of filtering of the original image in order to get a restored or enhanced image. Image enhancement techniques fall into two main categories, namely spatial domain methods and frequency domain methods. Spatial domain methods work on the principle of directly manipulating image pixels, whereas frequency domain methods are based on altering the Fourier transform of the image. As Mammograms are black and white x-rays of a compressed breast, they are low contrast images, so it is important to pre-process the images. The reason why images need to be pre-processed is so that intensity differences between objects and background can be increased and to enable clearer views of breast structures (Rajathi and Rangarajan, 2012; Molloy, 2009).

Noise

Noise is the result of errors in the image, and there is three major source of noise:

1. If the image is scanned from a photograph made on film, the film grain is a source of noise. Noise can also be the result of damage to the film, or be introduced by the scanner itself.
2. If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise.
3. Electronic transmission of image data can introduce noise.

There are several noise types such as:

1) Speckle noise: It is also known as multiplicative noise. It is similar to phasors with random amplitude and phase in free space; the speckle noise can be treated as infinite sum of independents.
2) Poisson noise: It is generated from the data of the original image instead of getting external effect.
3) Gaussian noise: It also known as normal noise. The scale of Gaussian noise is independent at each pixel and independent of the signal intensity. By using small amount, every pixel in the image will be changed from its original value (Rafael and Richard, 2002).

Noise reductions

Noise reduction is the process of removing noise from a signal. Medical images are corrupted with different kinds of noises with image acquisition. Sometimes mammograms can be affected by noise which can be random in nature, that is, white Gaussian noise, as a result of the X-ray system or the digitizing camera used. Although the images in the MIAS database do not suffer from noise, Poison noise, Speckle noise, and Gaussian noise were added to the images to simulate the effect. Noise reduction is then preformed using different filters, whereas image de-noising was done by filtering (Kaur and Sharma, 2013). Filters are methods used to correct or modify an object. In this area, filters are used to correct or restore an image corrupted with noise.

Noise image is a corrupted binary image needed by the filtering technique to restore the image; this operation is done by throwing some pixels from the image and replaced with random gray values. In some images, the noise will not be a big matter if it is in the low level, but when it has high level of noise it will be unwanted noise;

hence, filtering method should take place to remove the unwanted noise. The types of filters that are treated in this study are:

1) Average filtering: It is useful for removing grain noise from a photograph. Because each pixel gets set to the average of the pixels in its neighborhood, local variations caused by grain are reduced.
2) Gaussian filtering: It is considered as a type of linear filter. In frequency domain, the blurring is achieved by attenuating a specific range of high frequency of image, as such the Gaussian filter was used.
3) Log filtering: It is a laplacian filter with a Gaussian filter; this filter does not acceptably affect noise, and it is also called Maxican hat function.
4) Median filtering: It is similar to using an averaging filter, in that each output pixel is set to an average of the pixel values in the neighborhood of the corresponding input pixel. However, with median filtering, the value of an output pixel is determined by the median of the neighborhood pixels, rather than the mean.
5) Wiener filtering: The wiener2 function applies a Wiener filter (a type of linear filter) to an image adaptively, thereby tailoring itself to the local image variance. In cases where the variance is large, wiener2 performs little smoothing, whereas in cases where the variance is small, wiener2 performs more smoothing (Jain, 2012; www.mathworks.com).

The statistical measurements, such as Root Mean Square Error (RMSE), Signal-to-Noise Ratio (SNR), and Peak Signal-to-Noise Ratio (PSNR) are used to evaluate the de-noising performance.

PSNR is defined as shown below using the maximum signal intensity *S*max and the mean square error MSE for the de-noise image and the reference image (Wang et al., 2008):

$$\mathrm{PSNR} = 10\ \log_{10}\ \left(\frac{S_{\max}^2}{\mathrm{MSE}}\right)$$

$$\mathrm{MSE} = \frac{1}{H \times L} \sum_{x=1}^{H} \sum_{y=1}^{L} (d(x,y) - o(x,y))^2$$

METHODOLOGY

Procedure of the program

TIF and JPG format of medical images were used for this study. Some filters (Average filter, Gaussian filter, Log filter, Median filter, and Wiener filter) were for de-noising the above images deformed by different types of noises (Poisson, Speckle, and Gaussian). In order to restore the noisy image, de-noising techniques were used with MATLAB programming.

At the first stage, noise was added individually to the cell image, and different types of filters were used to remove this noise from the image. At the second stage, same step was applied on the breast image. At the final stage, the result of using all filters with different types of noises on the cell and breast images was compared, by using image quality parameters such as: MSE, SNR, and PSNR for all images in order to know the best filter for removing the noise in medical images.

Design of the program

This study explains the design of the program and how it is run as an important function. The related aspect of the program was applied on the medical images of (cell and breast) that have the different formats (‘tif’, ‘jpg’), which are used in Figure 1.

1. Read image:
Imread: read image from graphics file.
I = imread (' input image.format ').
2. Add noise:
Imnoise: add noise (Poisson, Speckle, and Gaussian) to an image.
In = imnoise (I,' noise type ', parameters).
3. Types of filters that were used:
Using filter (Average, Gaussian, Log, Median, and Wiener) for de-noising images deformed by different types of noises.
h = fspecial ('filter type', parameters);
J = imfilter (In, h);
4. Subplot the image (original image, noisy image, and filtered images) in order to get multi image in one single frame: subplot (3, 3, 1);
- Show the input image:
imshow (I), title (' a. Original Image ');
5. Evaluate image quality after applying the filter
[MSE, SNR, P_SNR]=Peak_SNR(In,J)

RESULTS AND DISCUSSION

At the first stage, the following filters (Average, Gaussian, Log, Median, and Wiener) were used on the original image (cell) to remove different types of noises (Poisson, Speckle, and Gaussian). It was found that all the filters have more ability and are successful in removing all the mentioned noises, as shown in Figures 2 to 4. On the other hand, in order to obtain the optimum filter on the original image (cell), it was found that the Gaussian filter has more ability and is more successful to remove noise; this depended on the image quality parameter of PSNR dB, because the value of PSNR has a maximum value for Gaussian filter. The results are listed in Tables 1 to 3, and are shown in Figures 5 to 7.

More so, it is observed that the filters (Average, Gaussian, Log, Median, and Wiener) were applied on the original image (breast) to remove different types of noises (Poisson, Speckle, and Gaussian). It was found that all the filters have more ability and are successful in removing all the mentioned noises, as shown in Figures 8

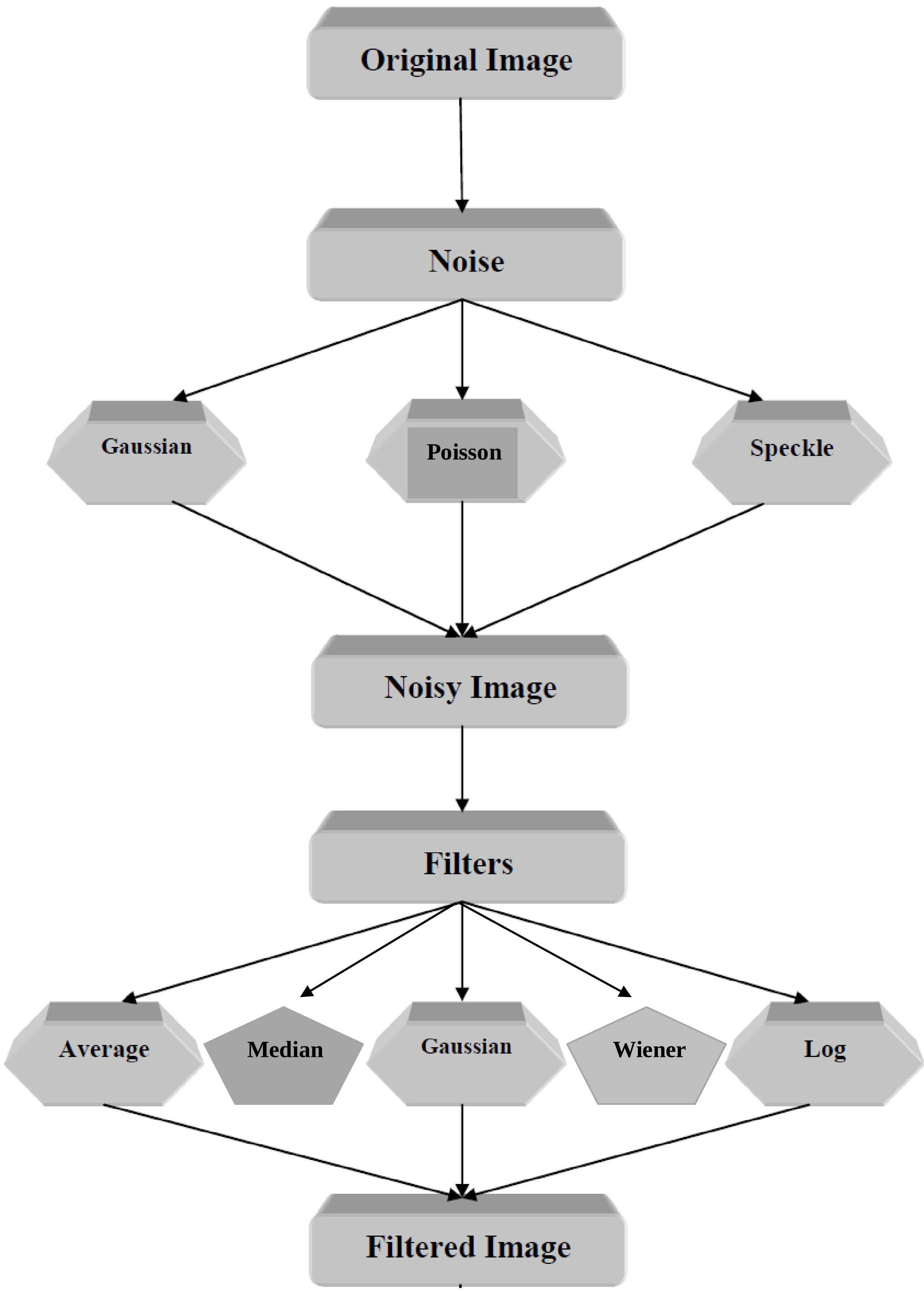

Figure 1. Representation of the implementation path of the code.

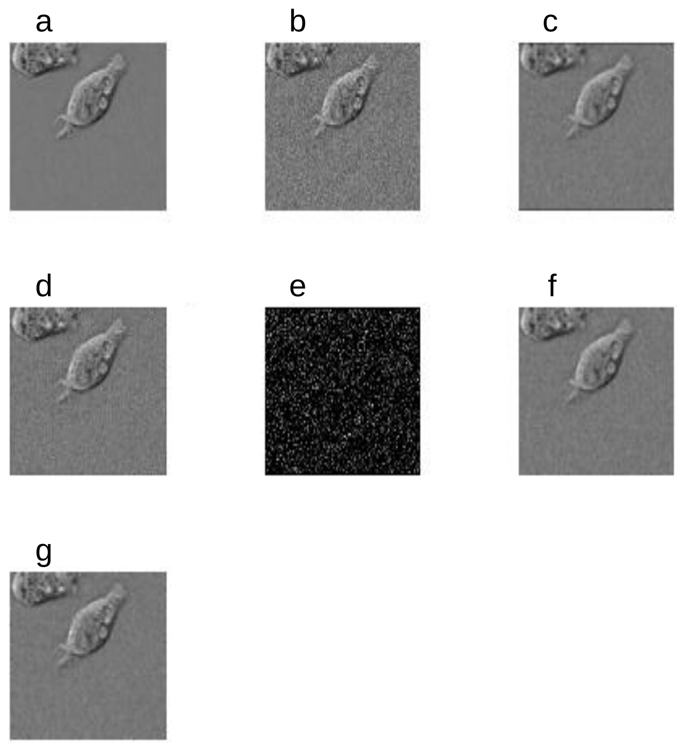

Figure 2. (a) Original image, (b) Noise image with Poisson noise, (c) Noise image filtered using Average filter, (d) Noise image filtered using Gaussian filter, (e) Noise image filtered using Log filter, (f) Noise image filtered using Median filter, and (g) Noise image filtered using Wiener filter of cell image.

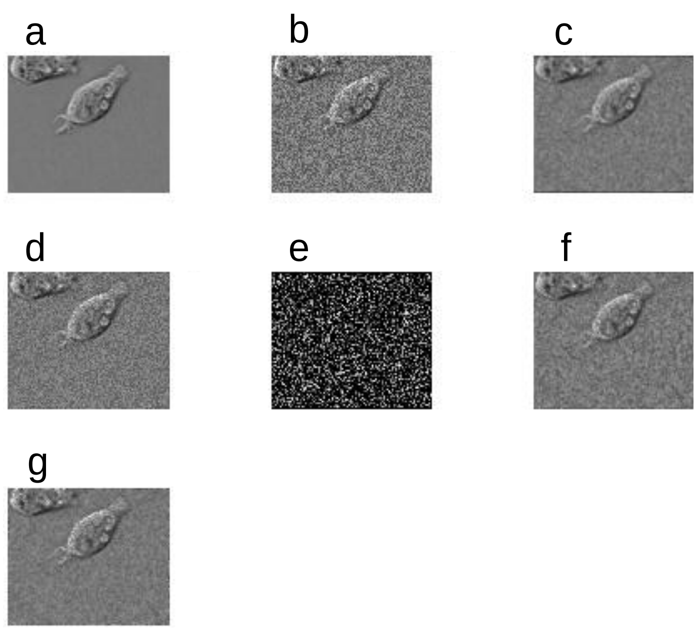

Figure 3. (a) Original image, (b) Noise image with Spickel noise, (c) Noise image filtered using Average filter, (d) Noise image filtered using Gaussian filter, (e) Noise image filtered using Log filter, (f) Noise image filtered using Median filter, and (g) Noise image filtered using Wiener filter of cell image.

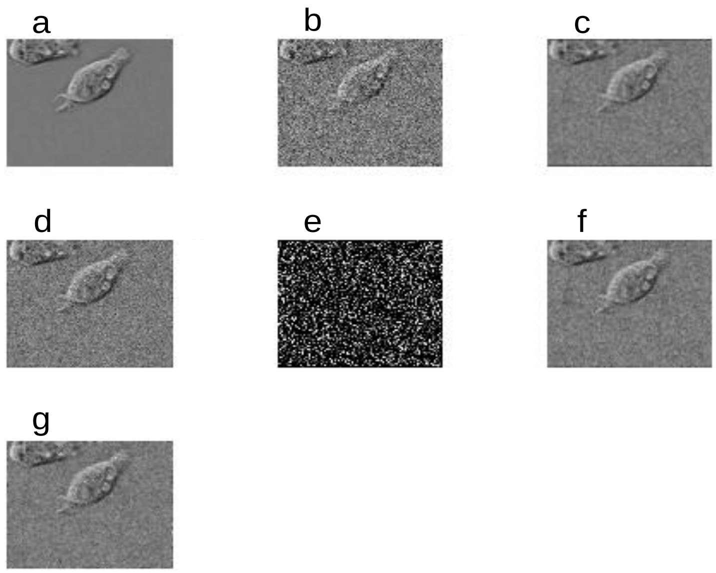

Figure 4. (a) Original image, (b) Noise image with Gaussian noise, (c) Noise image filtered using Average filter, (d) Noise image filtered using Gaussian filter, (e) Noise image filtered using Log filter, (f) Noise image filtered using Median filter, and (g) Noise image filtered using Wiener filter of cell image.

Table 1. Image quality parameters by the Average, Gaussian, Log, Median, and Wiener filters, with Poisson noises applied on the cell image.

Filter type	MSE	SNR	PSNR dB
Average	153.2611	9.8477	24.2956
Gaussian	25.6529	13.7291	32.8747
Log	1.1257e+004	0.5178	7.6167
Median	123.3547	10.3190	25.3658
Wiener	99.8483	10.7781	26.8550

Table 2. Image quality parameters by the Average, Gaussian, Log, Median, and Wiener filters, with Speckle noises applied on the cell image.

Filter type	MSE	SNR	PSNR dB
Average	558.0185	7.1139	19.3820
Gaussian	104.8313	10.7446	27.4354
Log	1.2726e+004	0.3237	7.0839
Median	527.3214	7.0475	19.2887
Wiener	423.4819	7.7129	21.3359

Table 3. Image quality parameters by the Average, Gaussian, Log, Median, and Wiener filters, with Gaussian noises applied on the cell image.

Filter type	MSE	SNR	PSNR dB
Average	621.3174	6.9770	18.8360
Gaussian	116.7739	10.6060	26.7109
Log	1.4071e+004	0.2019	6.6476
Median	622.2899	6.9736	18.8690
Wiener	436.5840	7.7432	20.3685

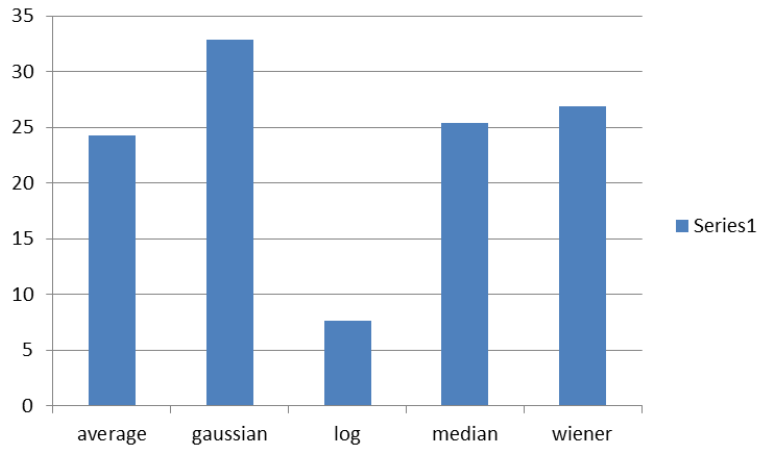

Figure 5. Histogram of PSN-R and several filters for cell image corrupted with Poison noise.

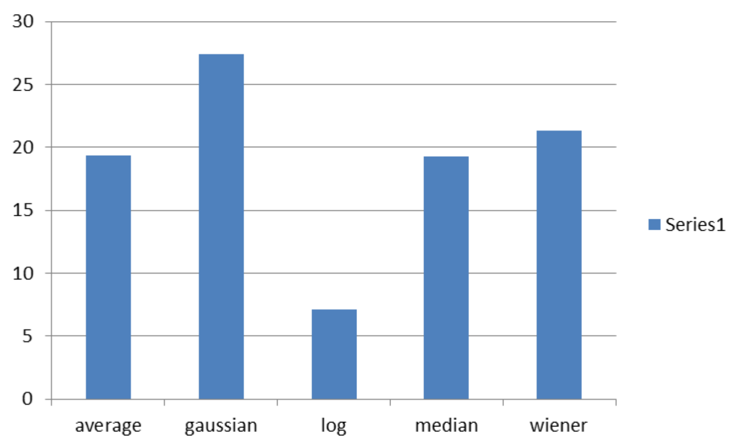

Figure 6. Histogram of PSN-R and several filters for cell image corrupted with Speckal noise.

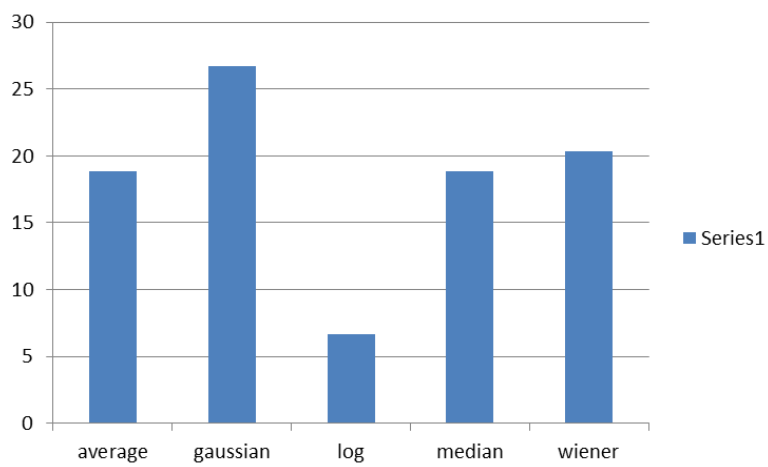

Figure 7. Histogram of PSN-R and several filters for cell image corrupted with Gaussian noise.

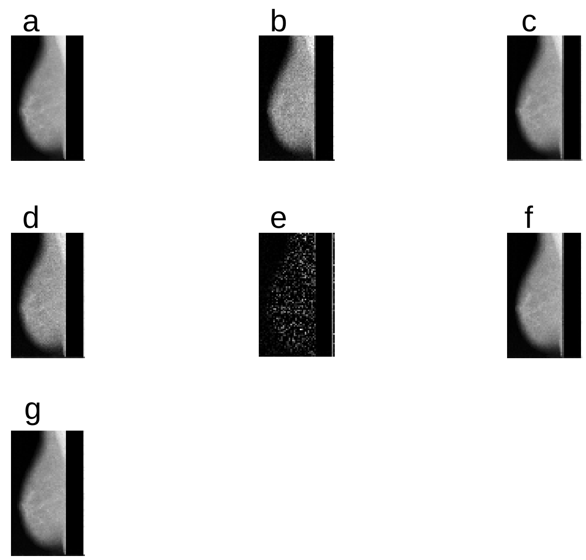

Figure 8. (a) Original image, (b) Noise image with Poisson noise, (c) Noise image filtered using Average filter, (d) Noise image filtered using Gaussian filter, (e) Noise image filtered using Log filter, (f) Noise image filtered using Median filter, and (g) Noise image filtered using Wiener filter of breast image.

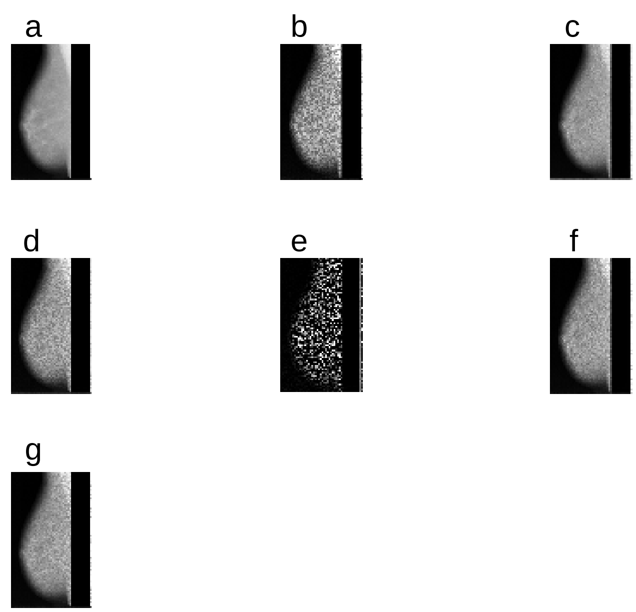

Figure 9. (a) Original image, (b) Noise image with Spickel noise, (c) Noise image filtered using Average filter, (d) Noise image filtered using Gaussian filter, (e) Noise image filtered using Log filter, (f) Noise image filtered using Median filter, and (g) Noise image filtered using Wiener filter of breast image.

to 10.

Finally, in order to obtain the optimum filter on the original image (breast), it was found that the Gaussian filter has more ability to remove noises, because the

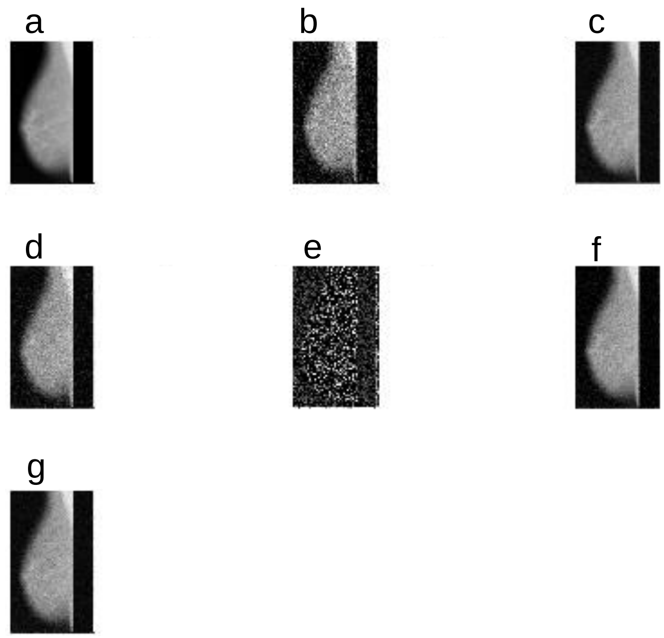

Figure 10. (a) Original image, (b) Noise image with Gaussian noise, (c) Noise image filtered using Average filter, (d) Noise image filtered using Gaussian filter, (e) Noise image filtered using Log filter, (f) Noise image filtered using Median filter, and (g) Noise image filtered using Wiener filter of breast image.

Table 4. Image quality parameters by the Average, Gaussian, Log, Median, and Wiener filters, with poison noises applied on the breast image.

Filter type	MSE	SNR	PSNR dB
Average	190.4595	8.8689	25.3328
Gaussian	25.2199	13.2592	34.1134
Log	9.8291e+003	0.3053	8.2057
Median	74.3285	10.9121	29.4192
Wiener	60.3457	11.3647	30.324396

Table 5. Image quality parameters by the Average, Gaussian, Log, Median, and Wiener filters, with Spekel noises applied on the breast image.

Filter type	MSE	SNR	PSNR dB
Average	465.6514	6.9396	21.4502
Gaussian	80.5775	10.7489	29.0687
Log	1.0109e+004	0.2564	8.0837
Median	402.3251	7.2571	22.0850
Wiener	189.2777	8.8944	25.3598

transition between the stop band and pass band is gradual, thus it does not agree with the result of the study of Wang et al. (2008).

The optimum filter depended on the image quality parameter of PSNR dB, because the value of PSNR has a maximum value for the Gaussian filter.

The results are listed in Tables 4 to 6, and are shown in Figures 11 to 13.

Table 6. Image quality parameters by the Average, Gaussian, Log, Median, and Wiener filters, with Gaussian noises applied on the breast image.

Filter type	MSE	SNR	PSNR dB
Average	525.7145	6.7994	20.9233
Gaussian	91.2396	10.6022	28.5290
Log	1.2139e+004	-0.0170	7.2890
Median	458.1525	7.0981	21.5207
Wiener	334.7319	7.7797	22.8838

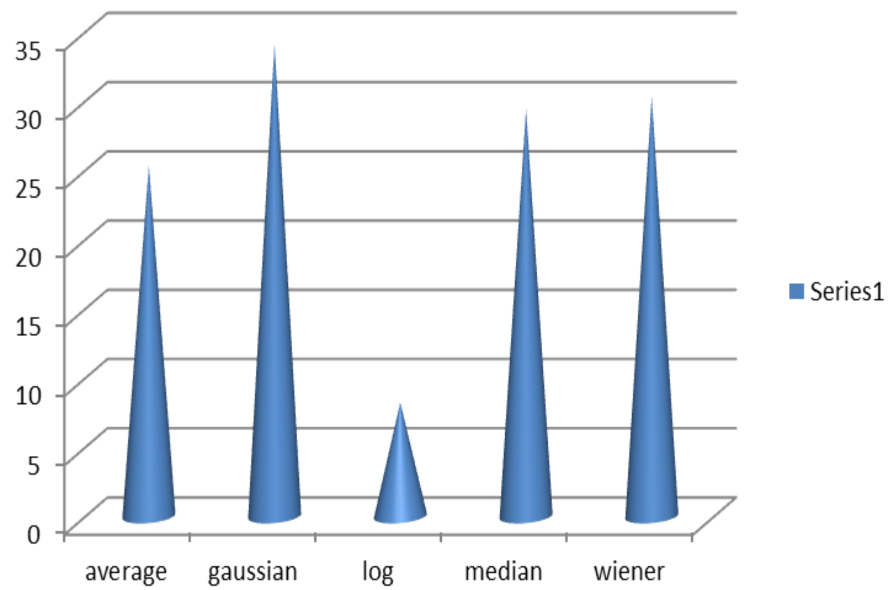

Figure 11. Histogram of PSN-R and several filters for breast image corrupted with Poisson noise.

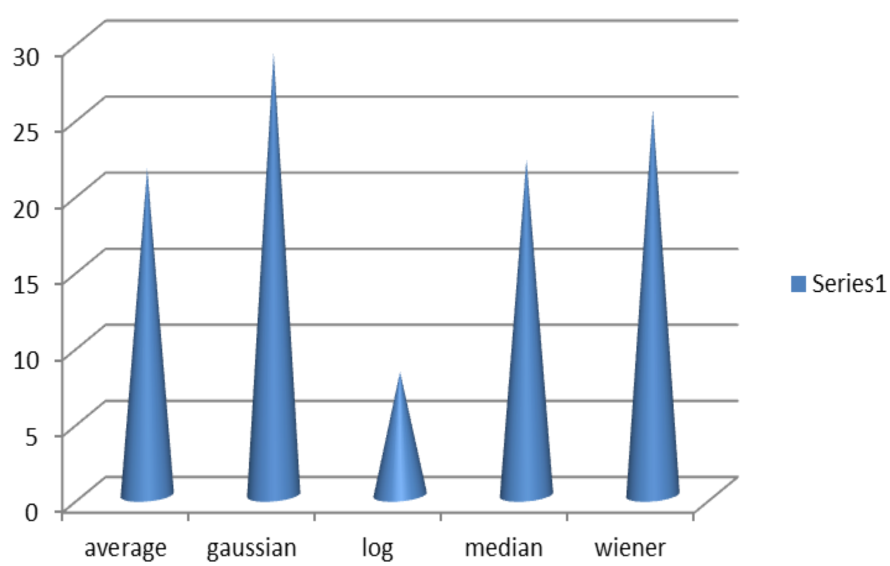

Figure 12. Histogram of PSN-R and several filters for breast image corrupted with Speckal noise.

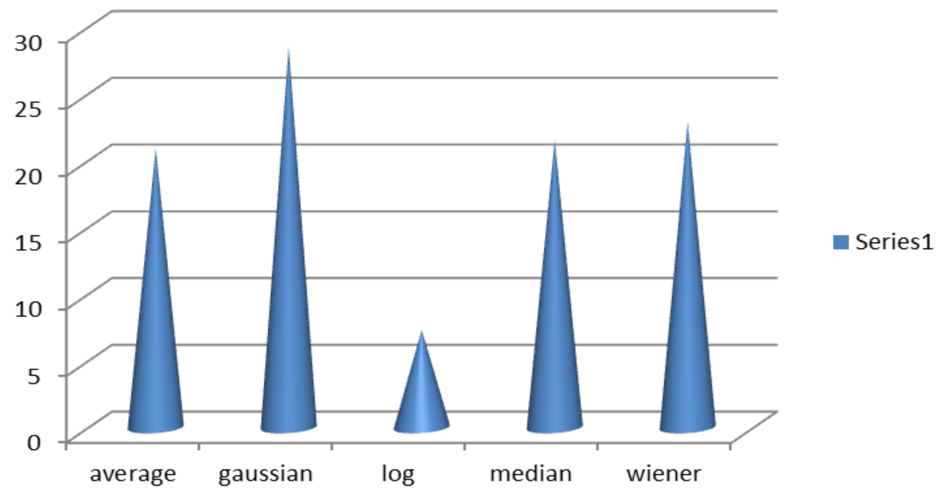

Figure 13. Histogram of PSN-R and several filters for breast image corrupted with Gaussian noise.

Conclusion

From the study's results, it can be concluded that:

1) This study shows the ability of restoring an image that is affected with different types of unwanted noises, by using various types of filters.
2) No type of filters was suitable for removing any type of noise; likewise the log filter was not suitable for removing any type of noise. However, the Gaussian filter had more ability to remove noises than the other filters.
3) It is assumed that the present codes could be able to de-noise the entire mentioned image format.

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