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Impact of Edge Detection Algorithms in Medical Image Processing

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ABSTRACT

Imaging technology in Medicine let the doctors to see the interior portions of the body for easy diagnosis. It also helped doctors to make keyhole surgeries for reaching the interior parts without really opening too much of the body. Noise in medical images appears in an image from a variety sources or it is the random variation of brightness or color information in images. Edge detection is a common process in the treatment of medical images and it is a very useful task for object recognition of human organs. Edge detection also show where shadows fall in an image or any other distinct change in the intensity of an image due to noise effects. In this paper we evaluated the performance of different edge detection algorithms; Canny, Prewitt, LOG, and Laplacian with and without adding filer such as wiener and median. The statement of effectiveness in removing noise and preserving important information in medical image is identified by using quality measurements like PSNR and MSE. Results show that the best algorithm for displaying edge and removing salt & pepper noise is the Prewitt Algorithm after using the median filter. Additionally, it was found that the best algorithm for displaying edge and removing Gaussian noise is the Canny algorithm after using the median filter.

Keywords: Canny, LOG, Laplacian, Prewitt, Salt & Pepper Noise, Gaussian Noise, Edge detection

1. INTRODUCTION

Digital images are utilized in a wide range of some fields like Security systems in face recognition, remote sensing systems, military applications and medical applications. The digital

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images play a vital part in the medical field as the importance of the medical images are increased in the medical field for different applications [1]. Medical image processing works to solve many of the problems facing medical images, the most common problems that are exposed to medical images is noise.

The most important ways that have been exposed to previous studies of noise elimination and reduction is the use of different filters linear and non-linear. The removal of a large amount of noise work to damage the important information in the medical images known as true edge. This paper will invent a new way to reduce noise from medical images while preserving the important information in medical images for edges correct by the techniques of detection edges; Canny, Laplacian, LOG and Prewitt.

The rest of this paper is organized as follows; Section 2 provides a brief concept on Noise in Medical image. In section 3 we reviewed the types of edge detection algorithms that we used in our experiments. The simulation model is illustrated in section 4, while the simulation results and discussion are reviewed in section 5. Finally, the paper concluded in section 6.

2. NOISE IN MEDICAL IMAGE

Medical images are analyzed for diagnosis of various diseases. But, they are susceptible to different types of noise. The noise present in the images will degrade the contrast of the image and creates problems in the diagnostic phase. Noise is an important factor which when get added to an image reduces its quality and appearance [2]. Here are many types of noises occurs in medical image such as:

2. 1. Impulse Noise

Impulse noise corruption is very common in medical images. Impulse noise is always independent and uncorrelated to the image pixels and is randomly distributed over the image. There are two types of impulse noise [3].

A. Salt & Pepper Noise

The salt-and-pepper noise is typically caused by errors in the data transmission malfunctioning pixel elements in camera sensors, faulty memory locations, or timing errors in the digitization process [4].

B. Gaussian Noise

The Gaussian noise is regularly used to model natural noise processes, for example those happening from electronic noise in the image acquisition system or framework [5].

2. 2. Poisson Noise

Poisson noise prevails in situations where an image is created by the accumulation of photons over a detector. Typical examples are found in standard X-ray films, CCD cameras, and infrared photometers [5].

2. 3. Speckle Noise

Another common form of noise is data dropout noise commonly referred to as Speckle noise. This noise is, in fact, caused by errors in data transmission. The corrupted pixels are either set to the maximum value, which is something like a snow in image or have single bits flipped over [6].

3. EDGE DETECTION

Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges [7]. There are different techniques for edge detection such as:

3. 1. Prewitt Edge Detection

The Prewitt edge detector is one of the classical operators used in image processing tools. it's an appropriate way to estimate the magnitude and orientation of an edge. Although differential gradient edge detection needs a calculation which is rather time consuming to estimate the orientation from the magnitudes in the x- and y-directions, the compass edge detection obtains the orientation directly from the kernel with the maximum response [8].

3. 2. Laplacian Edge Detector

The Laplacian operator is a second order derivative operator used for edge detection. It is from the zero-crossing category of the edge detection technique. It yields better edge localization when compared with first order derivative-based edge detection techniques but it is sensitive to noise [9].

3. 3. LOG Edge Detection

LOG algorithm work to detect edge point of an image by finding the zero crossing of second derivative of the image intensity, but the second derivative is very sensitive to noise, this mean that noise should be filtered out before edge detection [10].

3. 4. Canny Edge Detection

Canny edge detector is regarded as one of the best edge detectors currently in use; it ensures good noise immunity and at the same time detects true edge points with minimum error. Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images [11].

4. SIMULATION MODEL

In this paper, the X-Ray images are tested after adding the salt & pepper and Gaussian noises to evaluate the impact and the performance of the most famous edge detection

algorithms; Canny, Prewitt, LOG and Laplacian with using two types of filtering, median and wiener filters. The simulation parameters are shown in the following Table 1.

Table 1. Simulation Parameters.

Parameters	Type
Image type	X-ray
Edge detection algorithms	Canny, Prewitt, Laplacian, LOG
Filters	median, wiener
Noise ratio	5, 25, 45, 65, 85 (%)
Noise type	Salt &pepper, Gaussian
Metrics	PSNR, MSE (dB)

5. SIMULATION RESULTS AND DISCUSSION

The edge detection algorithms have been evaluated by using X-Ray image in MATLAB. The results are divided into two scenarios; scenario 1 for evaluate the impact of edge algorithms in noised image reduction and scenario 2 to evaluate the edge detection with filtering [12-16].

5. 1. Scenario1: Impact of Edge Detection Algorithms in Medical Image Without Filtering

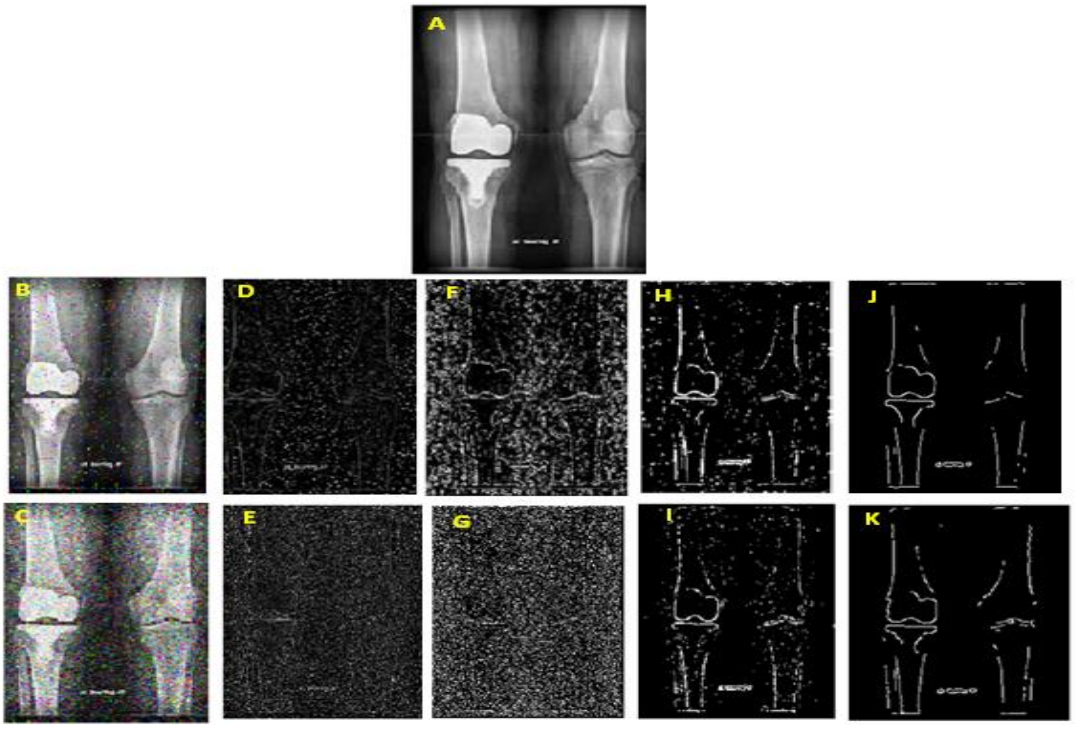

Figure 1. A. Original X-Ray Image, B. X-Ray Image with salt & pepper noise, C. X-Ray image with Gaussian noise, D. Laplacian edge detected (salt & pepper), E. Laplacian edge detected (Gaussian), F. LOG edge detected (salt & pepper), G. LOG edge detected (Gaussian), H. Perwitt edge detected (salt & pepper), I. Perwitt edge detected (Gaussian), J. Canny edge detected (salt & pepper),K. Canny edge detected (Gaussian).

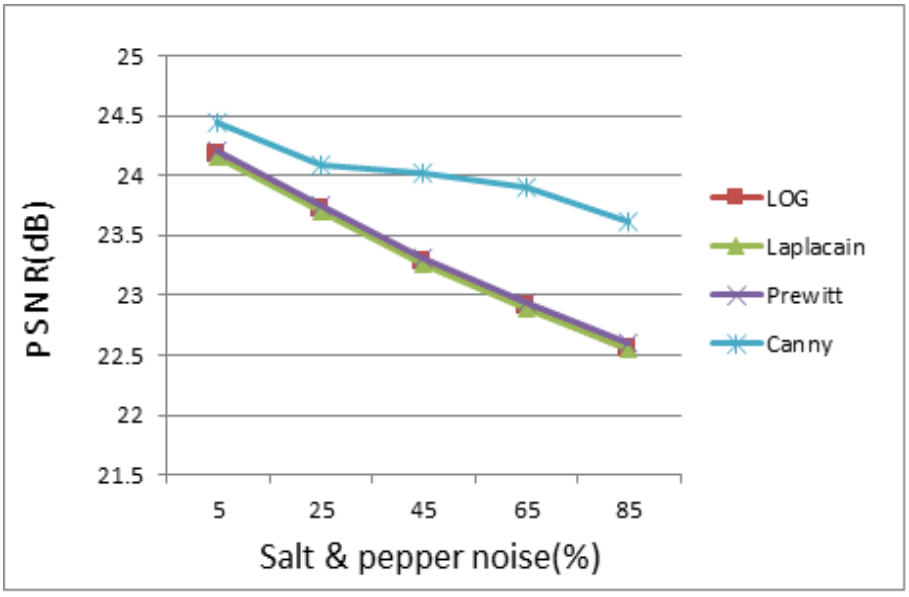

Figure 2. PSNR of Edge Detection Algorithms Without Filtering for Salt & Pepper Noise

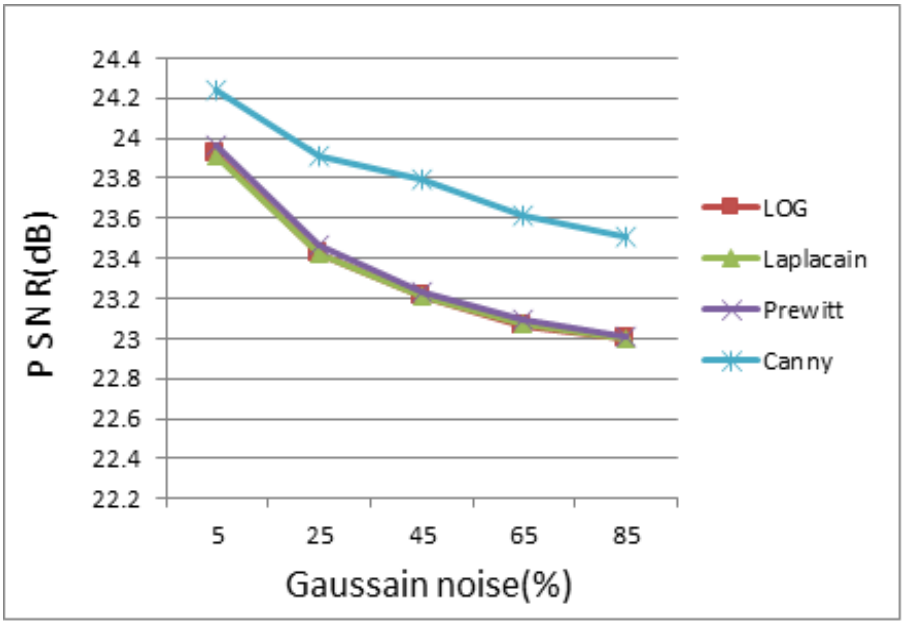

Figure 3. PSNR of Edge Detection Algorithms Without Filtering for Gaussian Noise

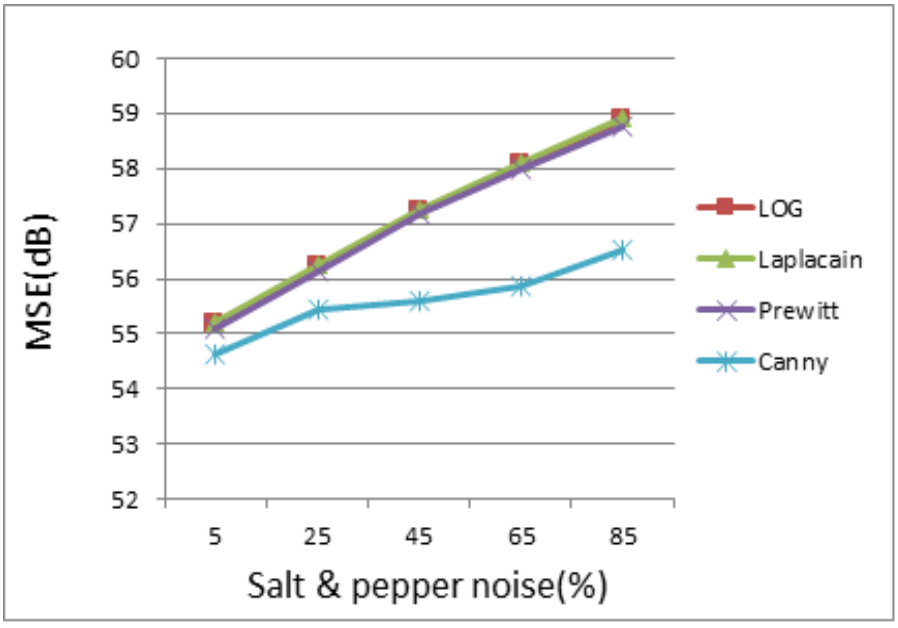

Figure 4. MSE of Edge Detection Algorithms Without Filtering for Salt & Pepper Noise.

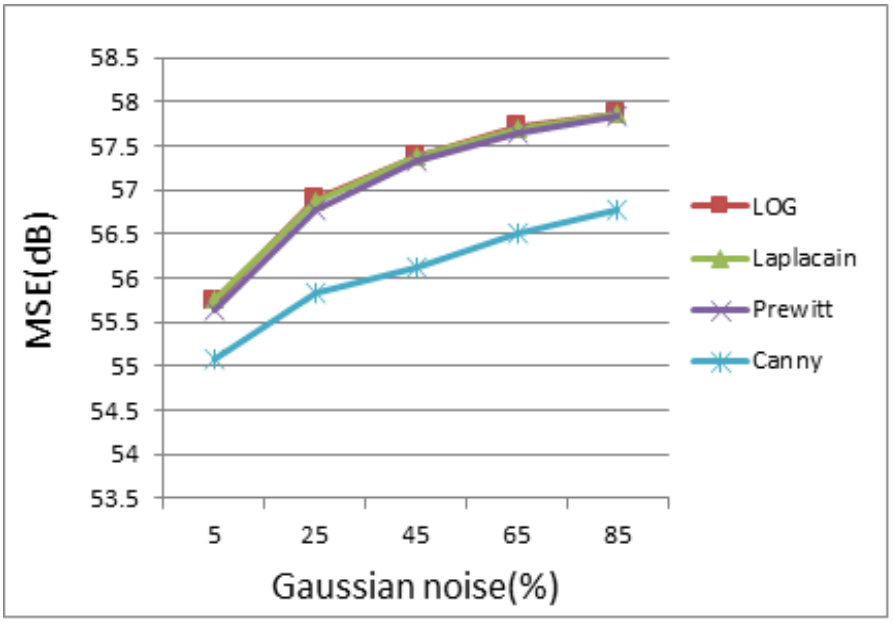

Figure 5. MSE of Edge Detection Algorithms Without Filtering for Gaussian Noise

Results of different edge detection techniques were compared when adding salt & pepper noise as well as Gaussian noise to the X-Ray medical as shown on the above figures. From the obtained results, it was concluded that the Laplacian and LOG algorithm are the worst edge detection algorithms in terms of eliminating the noise of both types. Moreover, the two algorithms led to loss of information (deformation of the edges) due to their sensitivity to

impulse noise as shown in Figure 1(D), figure F(E), Figure1(F), and Figure 1 (G). Prewitt algorithm performed better according to its higher PSNR value and smaller MSE value compared to Laplacian and LOG algorithms as shown in Figure 1(H). Figure 1 (I), and Figures 2, 3, 4 and 5 above. Although that Prewitt algorithm was able to detect the edges to some extend compared to the previous two algorithms, it failed to have a perfect edge detection and was not able to remove the noise of both types. On the other hand, Canny algorithm had a much better performance compared with Prewitt algorithm, and this is attributed to the fact that Canny algorithm contains a Gaussian filter which help removing impulse noise before starting the edge detection process. This superior performance is indicated by the large PSNR value (see Figures 2, 3) and the small MSE value (see Figures 4, 5) as observed in Figure 1 (J) and Figure 1(K). In addition to that, Canny algorithm was able to remove noise of both types but with some hidden edges.

5. 2. Scenario 2: Impact of Edge Detection Algorithms in Medical Image with Filtering

In this scenario we divide the impact evaluation in two sections; A. the performance of edge detection algorithms with mean filter, and section B. with wiener filters as follows;

A. Performance of Edge Detection Algorithms with Wiener Filter

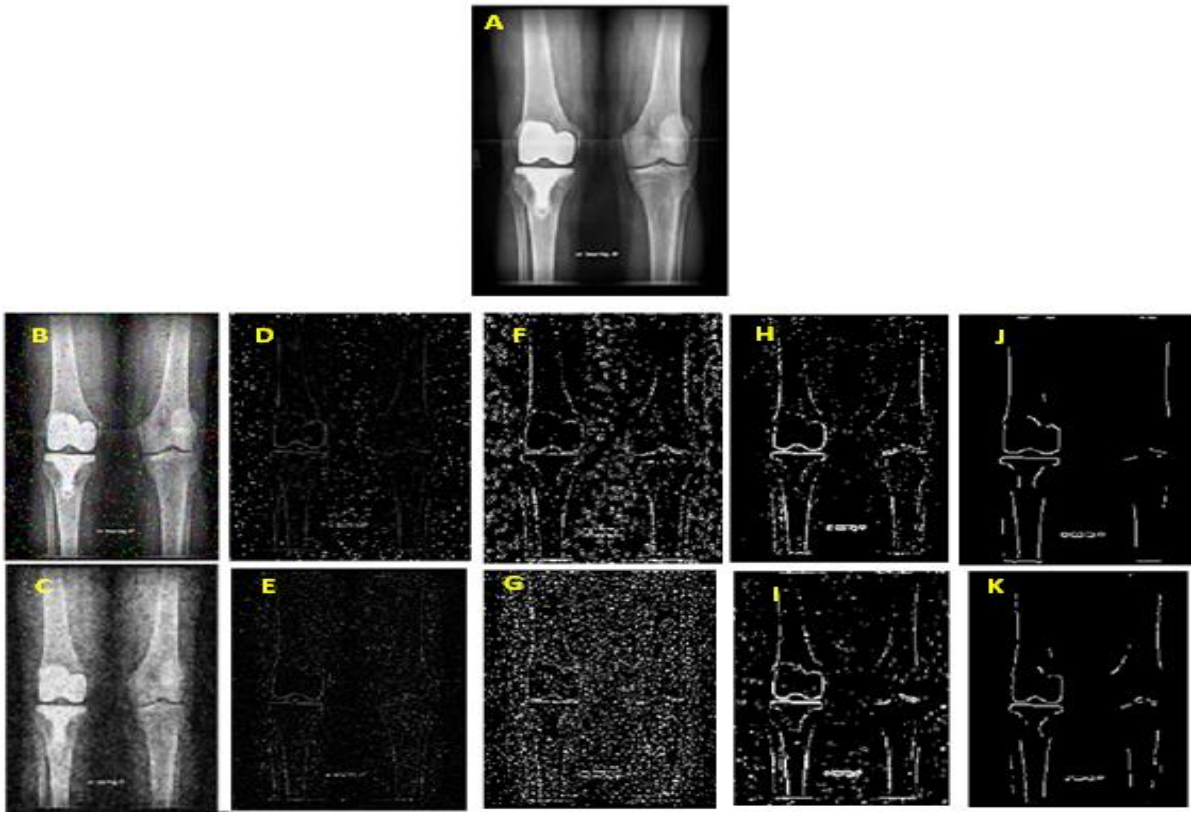

Figure 6. A. Original X-Ray Image, B. X-Ray Image with salt & pepper, C. X-Ray image with Gaussian noised. Laplacian edge detected (salt & pepper), E. Laplacian edge detected (Gaussian), F. LOG edge detected (salt & pepper), G. LOG edge detected (Gaussian), H. Perwitt

edge detected (salt & pepper), I. Perritt edge detected (Gaussian), J. Canny edge detected (salt & pepper), K. Canny edge detected (Gaussian).

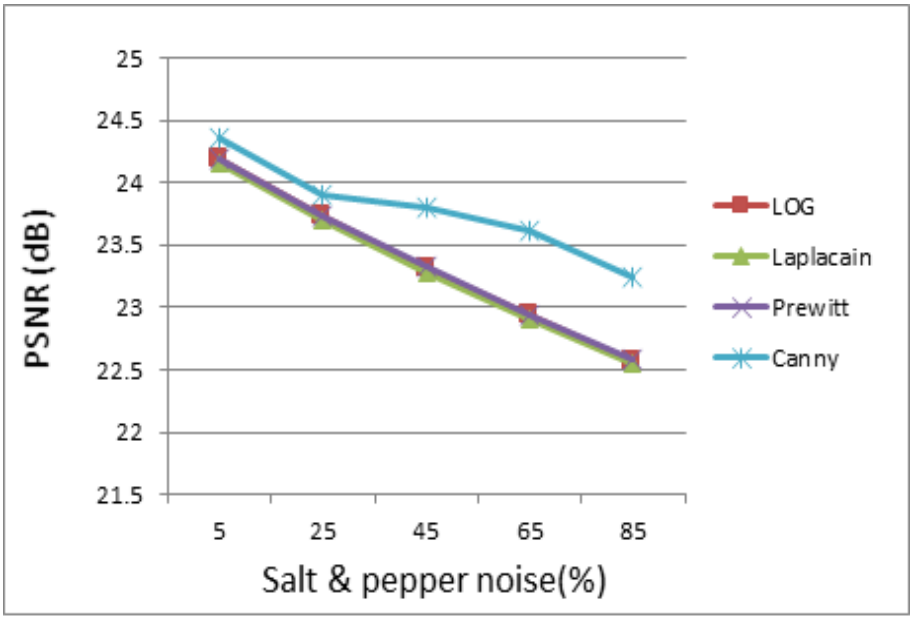

Figure 7. PSNR of Edge Detection Algorithms with Wiener Filter for Salt & Pepper Noise.

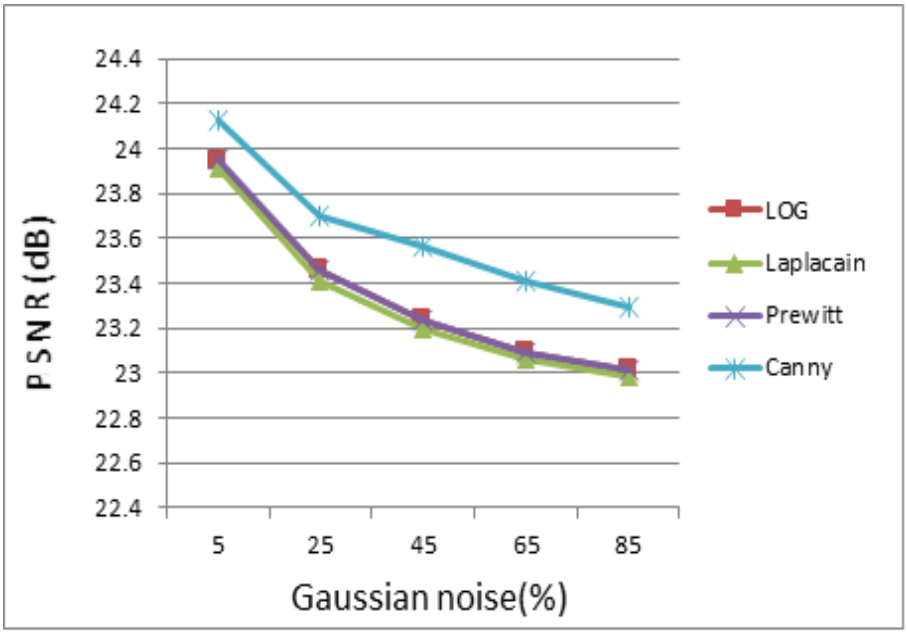

Figure 8. PSNR of Edge Detection Algorithms with Wiener Filter for Gaussian Noise

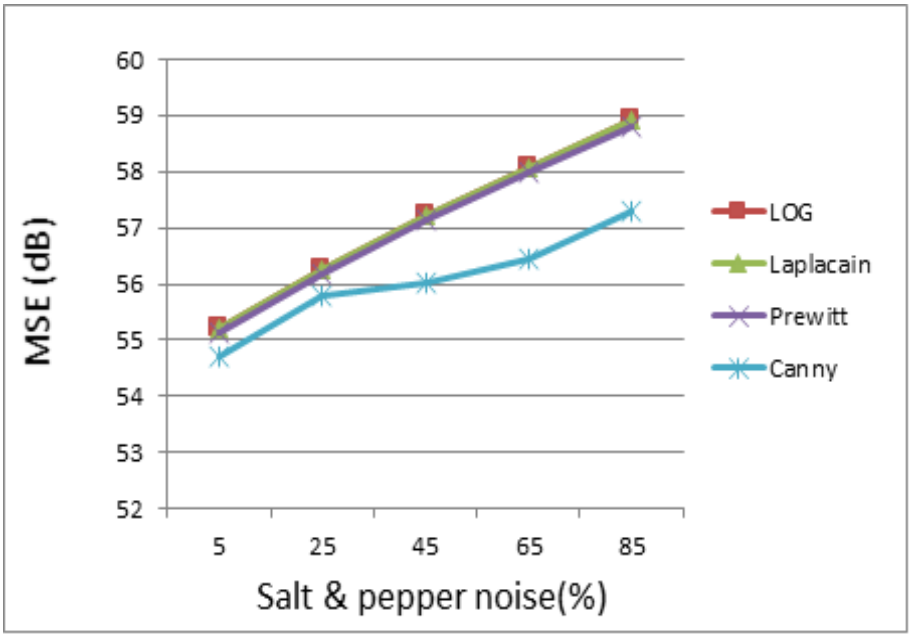

Figure 9. MSE of Edge Detection Algorithms with Wiener Filter for Salt & Pepper Noise

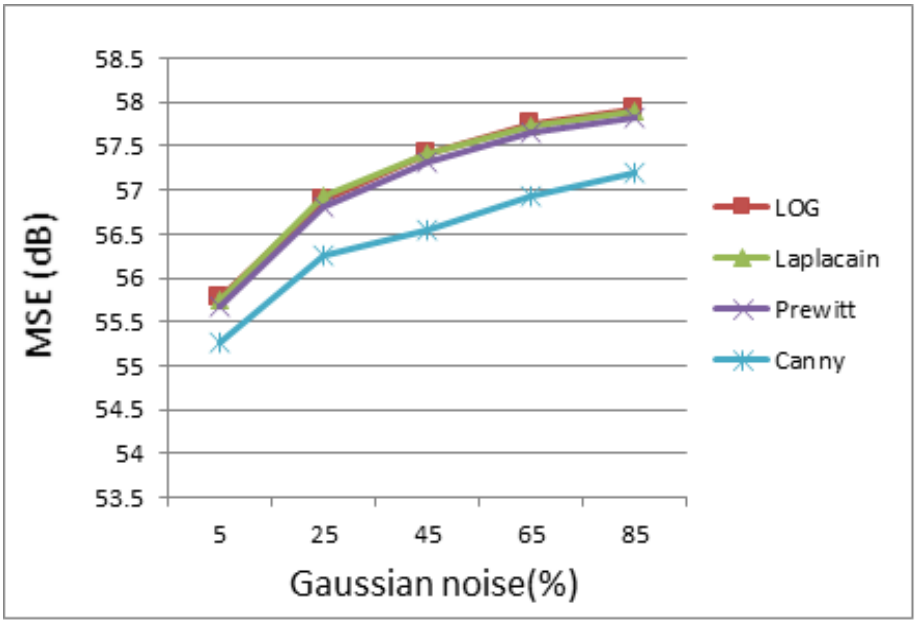

Figure 10. MSE of Edge Detection Algorithms with Wiener Filter for Gaussian Noise

The obtained results from the different edge detection techniques are compared after removal of the noises salt & pepper and Gaussian noise using a wiener filter. As shown in figure 6, the worst algorithms are Laplacian and LOG as they couldn't detect edges and were not able

to remove both types of noise Salt & pepper, and Gaussian noise. Both algorithms are approximated in PSNR and MSE values as shown in Figure 7, 8 ,9 and Figure10.

On the other hand, Prewitt algorithm with wiener filter is better according to its higher PSNR value and smaller MSE value compared to all of Laplacian and LOG algorithms with Wiener filter as illustrated in figures above. Prewitt algorithm with wiener filter was able to detect edges of the X-Ray image which are distorted by the noises. Similar to scenario 1, Perwitt algorithm failed to detect the image edges correctly and was not able to remove the noise of both kinds from noisy image. As previously demonstrated in scenario 2, Canny algorithm with wiener filter was better than Prewitt algorithm with wiener filter in terms of PSNR and MSE values. Nevertheless, Canny algorithm with wiener filter did not clarify the edges well. This was due to operation of two filters together. First, the wiener filter works to remove part from noise of both types, the noise removal process led to the hiding of the edges and the second filter was the Gaussian filter cause damage to pixel edges or destruction of information contained in noisy images.

B. Performance of Edge Detection Algorithms with Median Filter

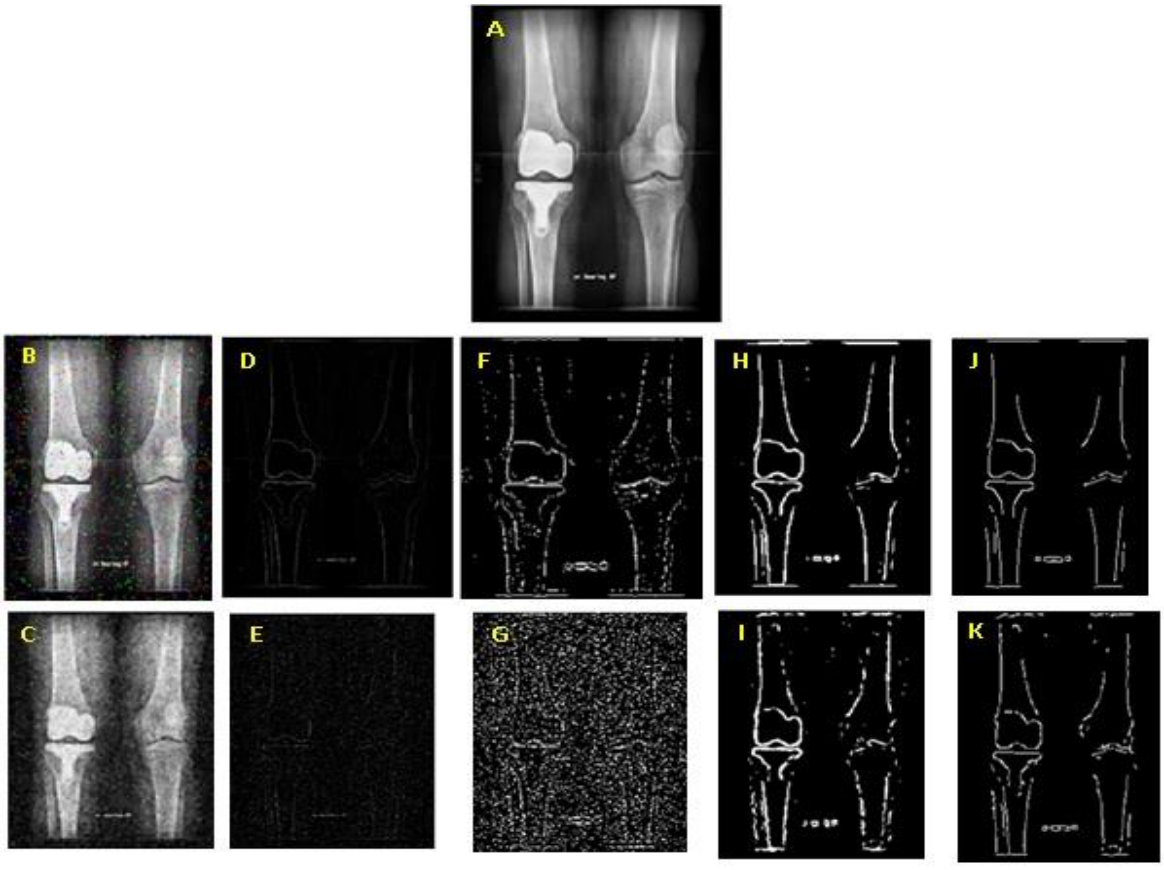

Figure 11. A. Original X-Ray Image, B. X-Ray Image with salt & pepper noise, C. X-Ray image with Gaussian noise, D. Laplacian edge detected (salt & pepper), E. Laplacian edge detected (Gaussian), F. LOG edge detected (salt & pepper), G. LOG edge detected (Gaussian), H. Perwitt edge detected (salt & pepper), I. Perwitt edge detected (Gaussian), J. Canny edge detected (salt & pepper), K. Canny edge detected (Gaussian).

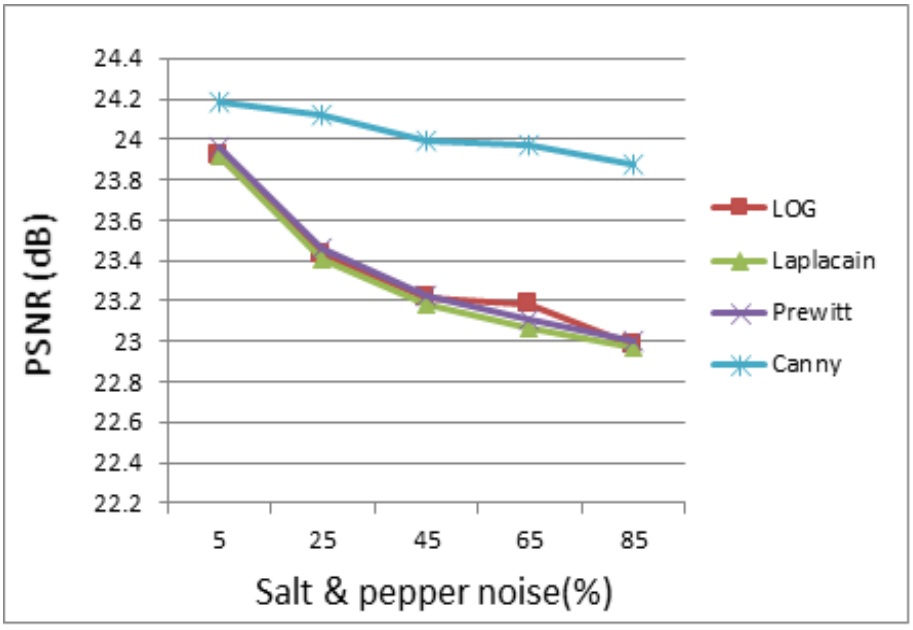

Figure 12. PSNR of Edge Detection Algorithms with Median Filter for Salt & Pepper Noise

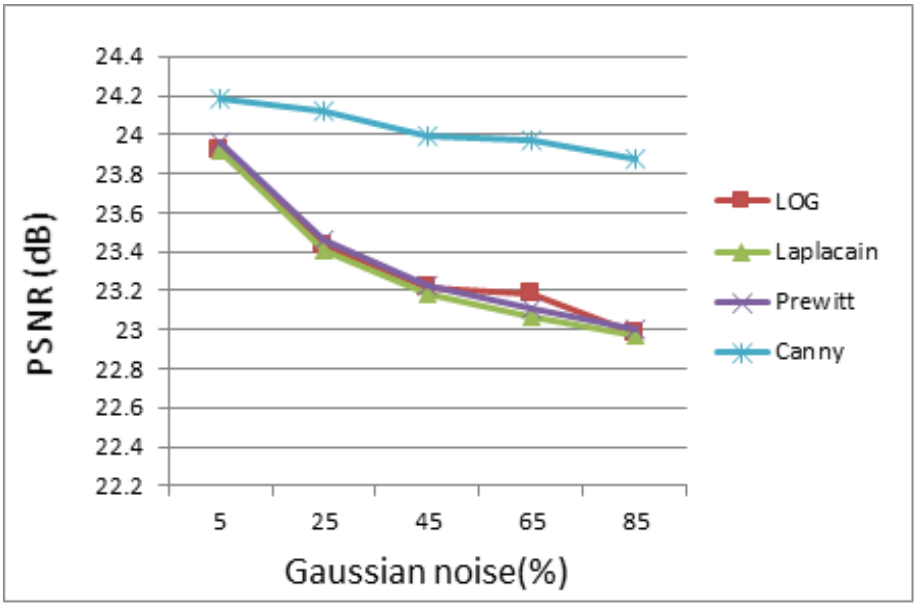

Figure 13. PSNR of Edge Detection Algorithms with Median Filter for Gaussian Noise

The observed results of different edge detection techniques are compared after removal of the noises using a median filter as shown in Figure11. Similarly, the obtained results showed that Laplacian and LOG algorithms are less effective. In the case image noised by salt & pepper, both algorithms detected the edges but failed to detect them properly, however, they remarkably

removed the salt & pepper noise. In the case of image noised by Gaussian noise, both algorithms resulted in edges' distortion and failed to eliminate Gaussian noise. Prewitt algorithm with median filter produced a good quality image compared with Laplacian and LOG algorithms; and in the case of images noised by salt and pepper, the algorithm perfectly showed the edges and removed the noise. Although Perwitt algorithm worked well on the image noised by Gaussian noise in terms of noise removal, it did not detect the images very perfectly.

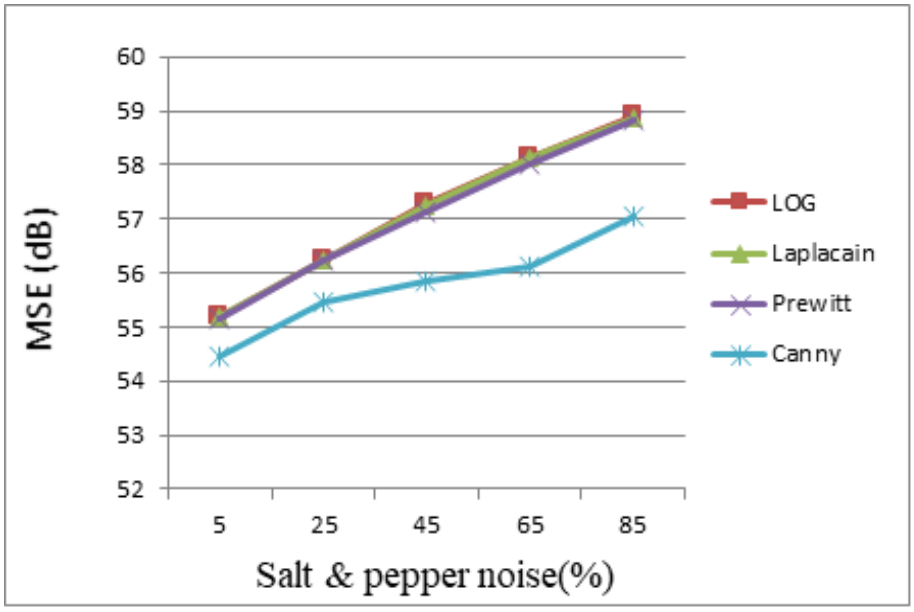

Figure 14. MSE of Edge Detection Algorithms with Median Filter for Salt & Pepper Noise

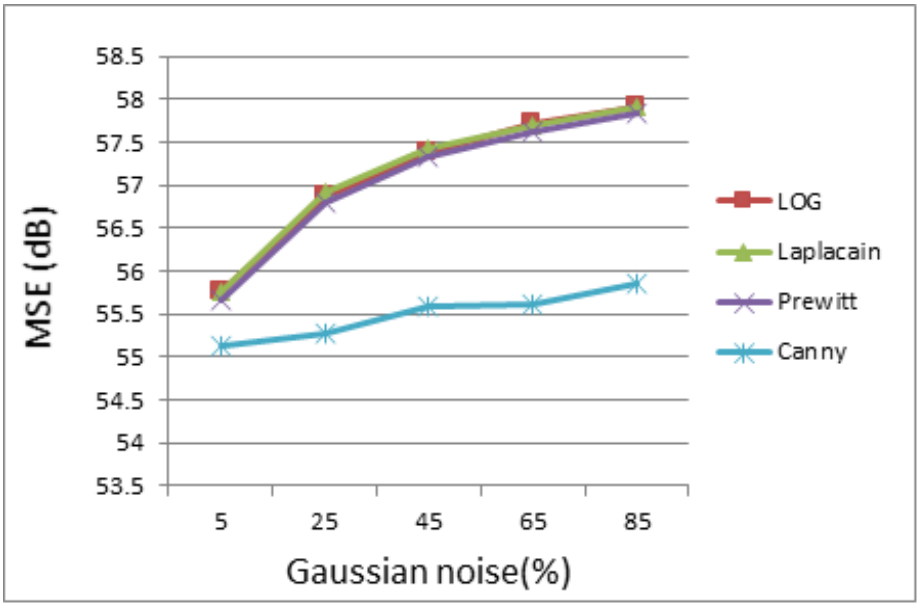

Figure 15. MSE of Edge Detection Algorithms with Median Filter for Gaussian Noise

Canny algorithm with median filter remained superior among all other edge detection algorithm and resulted in much better images' quality. In the case image noised by salt and pepper, the algorithm removed the salt & pepper noise. Although that Canny algorithm with median filter is better in terms of PSNR and MSE values as shown in Figures 12, 13, 14, and figure 15, however, the Prewitt algorithms with median filter was found to be better according to the output images. In case of Gaussian noise, Canny algorithm with median filter showed the edges the important information and removed noise significantly. better according to the output images.

6. CONCLUSION

From the obtained results it has been found that the Prewitt, Laplacian, LOG algorithms do not remove the noise of the image significantly compared to Canny algorithm which was found to be much better in removing most of the noise from medical images while hiding some of the edges of the images. By adding the wiener filter to the different detection algorithms, there were no remarkable changes. This is mainly because the Wiener filter worked on removing noise but distorted the edges. On the other hand, by adding a median filter to the edge detection algorithms it will help improving their performance in the case of salt & pepper noise; and this is mainly because the median filter is a specialized filter for removing noise of salt & pepper and also has an edge control. However, this superior filter might vary the contrast degree value of the edge.

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