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PERFORMANCE ANALYSIS OF BONE IMAGES USING VARIOUS EDGE DETECTION ALGORITHMS AND DENOISING FILTERS

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ABSTRACT

Image preprocessing and image segmentation are two important and broad research areas. Image denoising is one of the research fields in the research area of image preprocessing which is used to remove noise from the images. This paper proposed a method to identify the best filter and best edge detection algorithm for digital x-ray bone images. Comparisons of various filters such as Mean, Median, Gaussian and Weiner over different types of noises such as Salt and Pepper noise, Gaussian noise, Poisson noise and Speckle noise are analyzed by measuring performance parameters such as Mean Square Error (MSE), Normalised Correlation Coefficient (NCC), Peak Signal to Noise Ratio (PSNR), Normalized Absolute Error (NAE), Average Difference (AD) and Structural Content (SC). Comparison of different types of edge detection algorithms is analyzed by measuring the speed of edge detection and manual analysis. The benchmark experimental results show that best filter and the best edge detection algorithm for digital x-ray bone images.

KEYWORDS:**Image preprocessing, Denoising filters, Edge detection algorithms, Image quality metrics.**

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1. INTRODUCTION

An image is defined or represented by an array of integers. A set of images that is obtained from various sources and from various formats is processed in to different types of processing techniques in order to obtain information. This process of technique to obtain information from images is called Image processing. Based on the information obtained from these processed images it can be helpful in various fields of applications. Image processing is applied in various fields such as medical industry, forensics, remote sensing, manufacturing and defence. Images that are required for the process are collected from various resources like laboratories, online database, hospitals etc. This is the first stage of process which is known as Image acquisition. Presence of noises on image is high while collecting images from various resources which lead to preprocessing. Image preprocessing includes various steps such as Image Denoising, Image Enhancement and Smoothing is more vital. Removing noise form an image is first and foremost steps which increases accuracy of results. Image enhancement is a process of improving the perception of the users and to provide good quality of images as input. This enhanced image leads to further process to obtain valuable information's. Segmentation is a method of splitting the image into different regions of pixels with similar attributes. Thresholding is the simplest form of segmentation technique. Simple threshold, Adaptive threshold, Colour threshold are some of the techniques. It is mainly used to identify the region of interest (ROI) of the image. Extracting features from the region of interest is very important and major step in image processing. These features are used to identif characteristic and parameters of image which helps in classification of images. In image processing, many works have been carried out in the research area of denoising and edge detection. Transmission Electron Microscopy (TEM) images are corrupted by noise during image acquisition. In order to remove the noise various filtering techniques such as bilateral filter, total variation filter and fuzzy histogram equalization are applied [1]. Similarly the past research works on image denoising from blood cell microscopy images [15], color images [5], and spatial images. The comparisons of various edge detection algorithms on different types of images have been analyzed. Some of parameters like Root Mean Square Error and Peak Signal Noise Ratio are measured in order to identifying the performance of edge detection algorithms. The content of this paper organized as follows: section 2 describes various types of noises and types of denoising filters, section 3 describes about various edge detection algorithms, section 4 shows design of the proposed system, section 5 provides implementation results, section 6 shows that implementation screen shots and section 7 focuses on conclusion followed by list of references.

II. TYPES OF NOISES AND DENOISING FILTERS

A. Salt & Pepper Noise

Salt & pepper noise can be identified in an image by the presence of black pixels in white regions and white pixels in black regions. The root cause of this type of noise is transmission bit errors and dead pixels etc. It is also called as replacement noise.

B. Gaussian Noise

Amplifier noise occurs mostly in dark areas of the image. It is independent of intensity and pixels. Blue color presence is more than red and green color in color cameras and it has maximum noise rate. A value from zero-mean Gaussian distribution is added to each pixel of an image.

C. Poisson Noise

Poisson noise which follows a Poisson distribution is formed by producing a Statistical Quantum Fluctuations in the lighter parts of an image. It is also called as photon noise. The noises are present at various pixels are independent. These noises mostly occur at radiography images.

D. Speckle Noise

Mean gray level is increased in speckle noise from local area of an image. Image interpretation and recognition is very difficult in this type of noise. Mean and Variance of local area and single pixel are proportional to each other values. Speckle is also known as or type of granular noise. Image denoising is major role in preprocessing step because processing of image without denoising will lead to inaccurate results. Denoising filters is used to remove noises completely or partially and enhances the image. The different types of filters that can be used to remove unwanted pixels as noise from the image are: Mean filter, Median filter, Gaussian filter and Wiener filter.

E. Mean filter

Intensity variations between pixels are reduced by mean filter which is used iintensity variation approach. Based on the mean value of neighbouring pixels replaced with each pixels in the row. This filter is also known as convolution filter or average filter.

F. Median filter

Initially all the pixels intensity values are sorted in numerical order in order to identify the middle value of pixel. This middle value of pixels is replaced with all other pixels values. It is a spatial filtering operation, which performed to identify the middle pixels value or median brightness value. Finally this filter changes mean value of an image.

G. Gaussian filter

Gaussian filter is also known as low pass filter (Non uniform). If the kernel centres in distance increase then the kernel coefficients decrease. Periphery is low when compared with weight of the centre pixel. Larger values of σ produce a wider peak which means greater blurring and hence Kernel size must increase with increase in σ to maintain the Gaussian nature of the filter. There exists a dependency between the Gaussian kernel coefficients and the value of σ. In the place of edge mask, coefficient values close to be zero. Gaussian filter is working based on the kernel values which gives fast computation and It should preserve brightness of image while removing noise. The Gaussian function for one dimension is given below:

$$G(X) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2}{2\sigma^2}}$$

Where σ is the standard deviation of the distribution.

H. Wiener Filter

Weiner filter is a way of finding best reconstruction of noisy signal. Weiner is used to some procedure such as inverse filtering and smoothing to reduce MSE value. Liner estimation framework approach is used in wiener filter to reduce noise from input image.

III. EDGE DETECTION ALGORITHMS

Edge detection is a part of image segmentation which is used to separate the region of interest accurately. Some common functionalityis needed for edge detection algorithms such as insensitive to noise, good location, object oriented, speed of detection and accuracy. In this paper, we made a comparative analysis of various edge detection algorithms.

A. Canny

Canny is an efficient algorithm because it follows some procedures to detect the edges.

Step 1: Noise removal is an important characteristic of edge detection algorithm. Canny performs smoothing operation in order to remove the noise.

Step 2: Gradient method is used to identify the strength of the pixels or intensity variations of pixels.

Step 3: Only the pixels with maximum grey level values are identified as edges.

Step 4: Double thresholding is applied in order to identify the minute edges.

Step 5: Edges are connected using suppression method.

B. Sobel

Sobel operator is used to identify gradients in horizontal and vertical directions and combine the information in to a single metric. For each pixel position in the image the gradient value is calculated. This operator consists of 3*3 kernel.

C. Roberts cross operator

It is used to measure spatial gradient on an image. The output image consists of 2*2 convolution kernels and It represents magnitude of input image.

D. Prewitt

It is used to detect horizontal and vertical edges of an image. It is similar to sobel operator and has 3*3 kernel.

E. Laplacian of Gaussian

It is a measure of spatial derivative of the image. It is mainly used in edge detection as it identifies the change of intensity in the image rapidly. The input for this operator is a gray image and output is also another gray level image. The kernel can be pre calculated and one convolution must be calculated during the process.

IV. SYSTEM DESIGN

In this work, Performance of various Edge detection algorithms is analyzed in order to identify suitable filter for digital x-ray images. Time taken by each edge detection algorithms is measured and some other parameters are considered to select suitable filter. More than 100 digital x-ray images are collected from various resources such as online database and hospitals. Initially original image is converted into gray image to simplify further processing. Figure 1 represents the flow of comparison of edge detection algorithms.

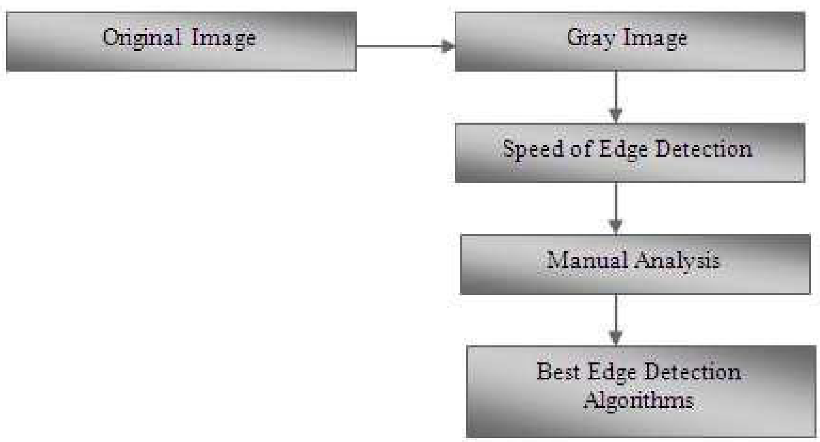

Figure 1
Flow diagram of edge detection algorithms

In order to evaluate the performance of various filters over different types of noise, image performance metrics such as Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Normalised Correlation Coefficient (NCC), Normalized Absolute Error (NAE), Average Difference (AD) and Structural Content (SC) are measured and compared. Figure 2 represents the flow of comparison of various denoising filters.

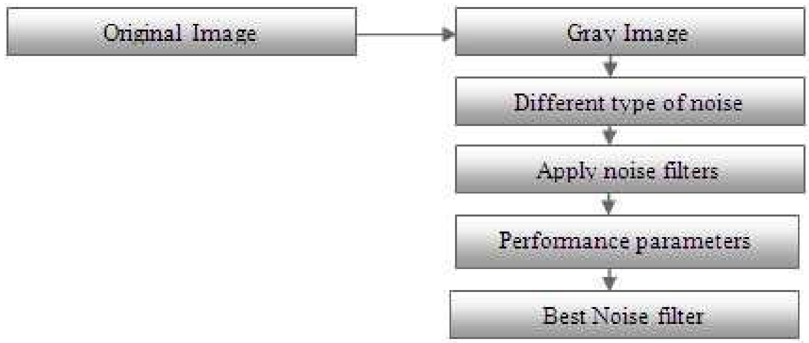

Figure 2
Flow diagram of various denoising filters

Mean Square Error (MSE)
MSE is given by

$$MSE = 1/MN \sum_{i=1}^{M} \sum_{j=1}^{N} ([g(i,f) - f(i,j)])^2$$

Where M and N are pixels in the row and column of image, g denotes noise image and f denotes filtered image. The filter with lowest MSE value represents best filter.

Peak Signal – to- Noise Ratio (PSNR)
PSNR is calculated by

$$PSNR = 20 \log_{10}\left(\frac{N}{\sqrt{MSE}}\right) db$$

If the filter with high PSNR value represents that best filter and image is best quality image.

Normalized Correlation (NC)
Normalized correlation is calculated by

$$NK = \sum_{i=1}^{M} \sum_{j=1}^{N} (g(i,j).\, g'(i,j)] / \sum_{i=1}^{M} \sum_{j=1}^{N} (g(i,j))^2$$

If the normalized cross correlation tends to 1, then the image quality is deemed to be better.

Normalized Absolute Error (NAE)
Normalized absolute error is calculated by

$$NAE = \sum_{i=1}^{M} \sum_{j=1}^{N} |[g(i,j).\, g'(i,j)]| / \sum_{i=1}^{M} \sum_{j=1}^{N} g(i,j)$$

Normalized absolute error should be the minimum in order to minimize the difference between original and filtered image

Average Difference (AD)
Average difference is calculated by

$$AD = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} g(i,j) - f(i,j)$$

If the filter with high AD value represents that best filter and image is best quality image.

Structural Content (SC)
SD is calculated by

$$SC = \sum_{i=1}^{M}\sum_{j=1}^{N}(g(i,j) * g(i,j)) / \sum_{i=1}^{M}\sum_{j=1}^{N}(f(i,j) * f(i,j))$$

The similarity between origin and filtered image is identified by structural content.

V. EXPERIMENTAL RESULTS

Original image is converted into gray image in order to apply each and every edge detection algorithm individually. Speed of edge detection by each algorithm is measured and Results are listed below:

TABLE 1
Speed of edge detection

Speed/ Algorithm	Time (Seconds)
Canny	0.1476
Sobel	0.0713
Log	0.0862
Roberts	0.0807
Prewitt	0.0795

Table 1 represents Speed of edge detection on gray image by each algorithm (Canny, Sobel, Log, Roberts and Prewitt) individually. This shows that canny edge detector takes more time when compared with other algorithms.

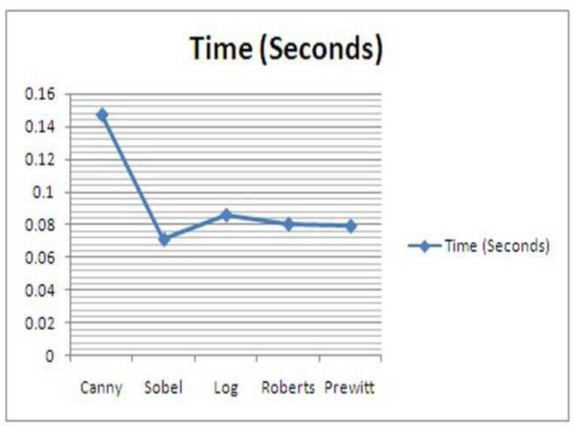

Figure 3
Graph for speed of edge detection

Figure 3 shows that speed of edge detection of various algorithms graphically. Graph plotted between various edge detection algorithms and Time taken by various algorithms. From the above experimental results, it can be seen that canny algorithm takes more time when compared with various algorithms such as Sobel, Log, Roberts and Prewitt. Canny is an efficient algorithm even though it takes more time because canny has some important characteristic like insensitive to noise and visual inspection is good.

TABLE 2
Image quality metrics for Salt and Pepper Noise

	MSE	PSNR	NCC	NAE	AD	SC
Mean	164.3460	25.9732	0.9897	0.0973	-1.3218	0.9929
Median	70.4113	29.6544	0.9789	0.0331	0.4757	1.0312
Weiner	220.9312	24.6882	0.9922	0.0975	-1.4839	0.9787
Gaussian	143.2453	26.5700	0.9881	0.0934	-1.3268	Inf

Table 2 represents the various image quality metrics such as MSE, PSNR, NCC, NAE, AD and SC for various filters (Mean, Median, Wiener and Gaussian) over salt and pepper noise.

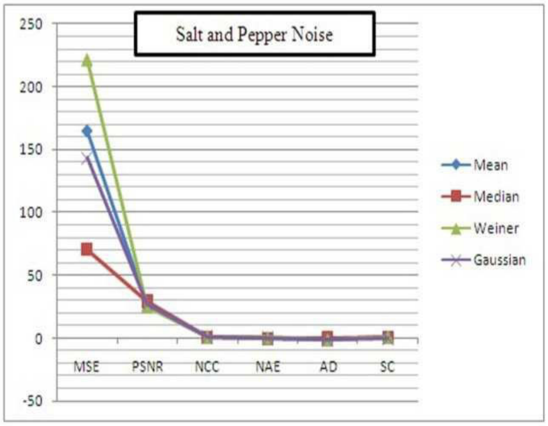

Figure 4
Graph for Salt and Pepper noise

In figure 4, graph is plotted between image quality metrics and various filters for salt and pepper noise obtained value from table 2.

TABLE 3
Image quality metrics for Gaussian Noise

	MSE	PSNR	NCC	NAE	AD	SC
Mean	163.2374	26.0026	0.9765	0.1273	-0.0159	1.0199
Median	198.3697	25.1560	0.9761	0.1423	0.4313	1.0146
Weiner	116.3888	27.4717	0.9801	0.0986	-0.1853	1.0206
Gaussian	141.7526	26.6155	0.9749	0.1165	-0.0185	Inf

Table 3 represents the various image quality metrics such as MSE, PSNR, NCC, NAE, AD and SC for various filters (Mean, Median, Wiener and Gaussian) over Gaussian noise.

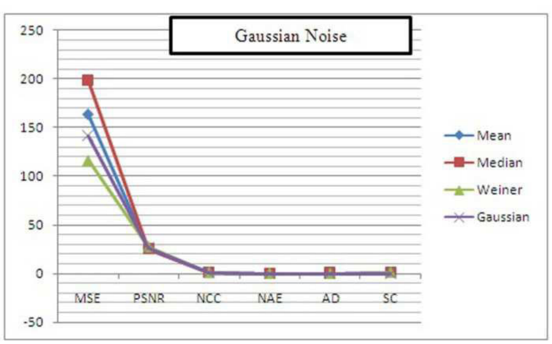

Figure 5
Graph for Gaussian noise

In figure 5, graph is plotted between image quality metrics and various filters for Gaussian noise obtained value from table 3.

TABLE 4
Image quality metrics for Poisson Noise

	MSE	PSNR	NCC	NAE	AD	SC
Mean	97.0661	28.2601	0.9750	0.0721	0.3366	1.0348
Median	84.4203	28.8663	0.9771	0.0652	0.5866	1.0327
Weiner	40.1417	32.0948	0.9879	0.0544	0.0467	1.0177
Gaussian	90.9551	28.5425	0.9734	0.0696	0.3343	Inf

Table 4 represents the various image quality metrics such as MSE, PSNR, NCC, NAE, AD and SC for various filters (Mean, Median, Wiener, and Gaussian) over Poisson noise.

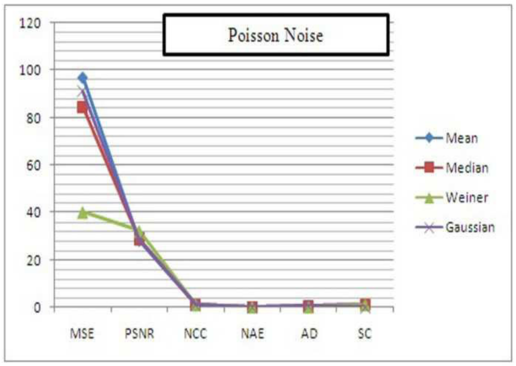

Figure 6
Graph for Poisson noise

In figure 6, graph is plotted between image quality metrics and various filters for poisson noise obtained value from table 4.

TABLE 5
Image quality metrics for Speckle Noise

	MSE	PSNR	NCC	NAE	AD	SC
Mean	102.0167	28.0441	0.9740	0.0761	0.4043	1.0360
Median	105.0161	27.9182	0.9710	0.0833	0.8968	1.0420
Weiner	55.8412	30.6613	0.9867	0.0617	0.1058	1.0174
Gaussian	94.5355	28.3749	0.9724	0.0727	0.4005	Inf

Table 5 represents the various image quality metrics such as MSE, PSNR, NCC, NAE, AD and SC for various filters (Mean, Median, Wiener and Gaussian) over speckle noise.

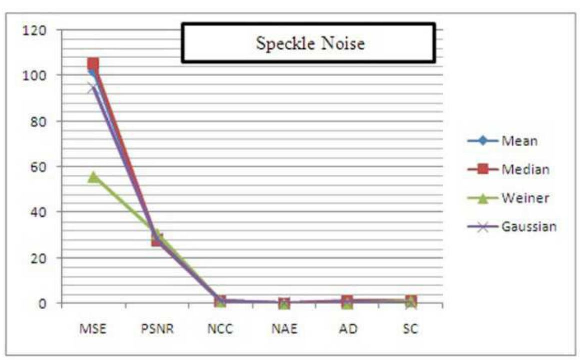

Figure 7
Graph for speckle noise

In figure 7, graph is plotted between image quality metrics and various filters for speckle noise obtained value from table 5.From the above experimental results, it can be seen that each filter gives good performance over various noise. But median and wiener filter gives better performance over all types of noise when compared with other filters. When comparing these two denoising filters it can be seen that median filter gives average performance on all types of noise.

VI. SCREEN SHOTS

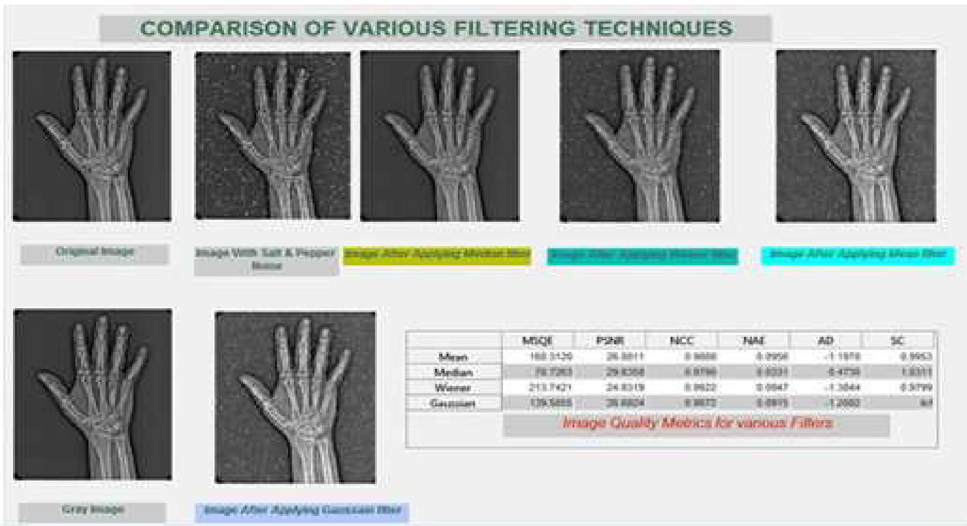

Figure 8
Screen shots for Salt and Pepper Noise

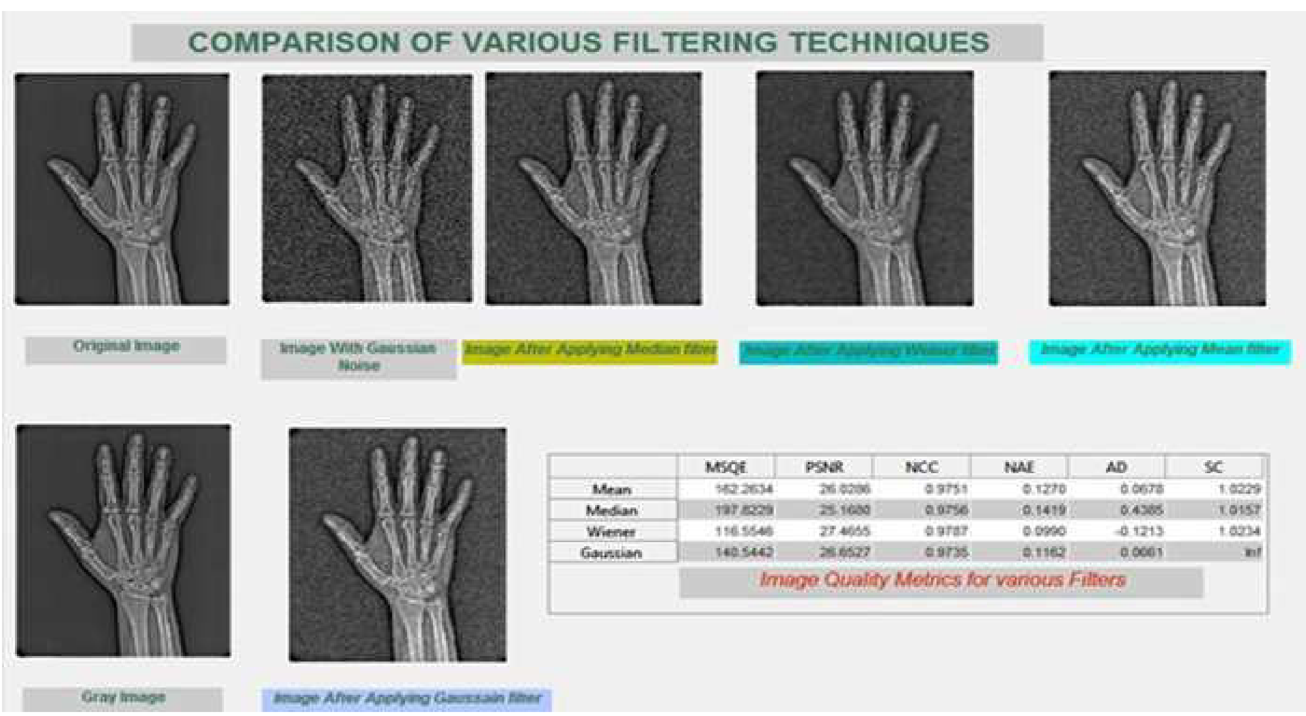

Figure 9
Screen shots for Gaussian Noise

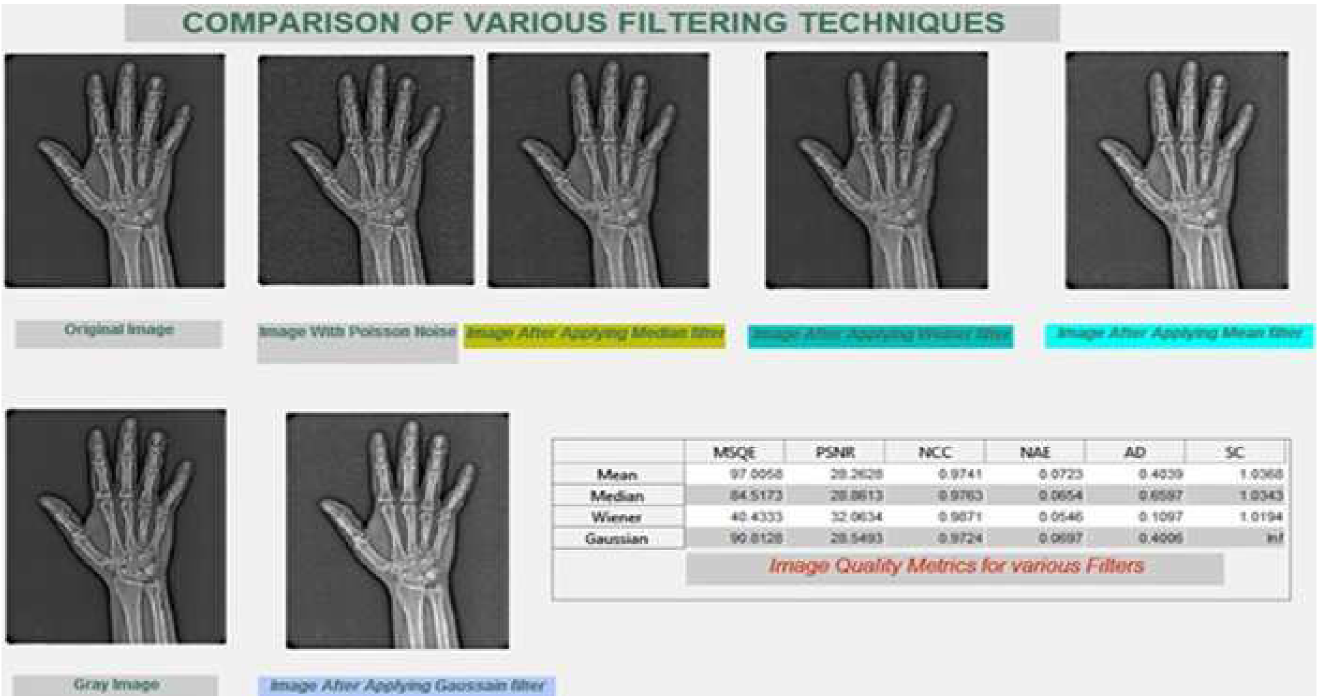

Figure 10
Screen shots for Poisson Noise

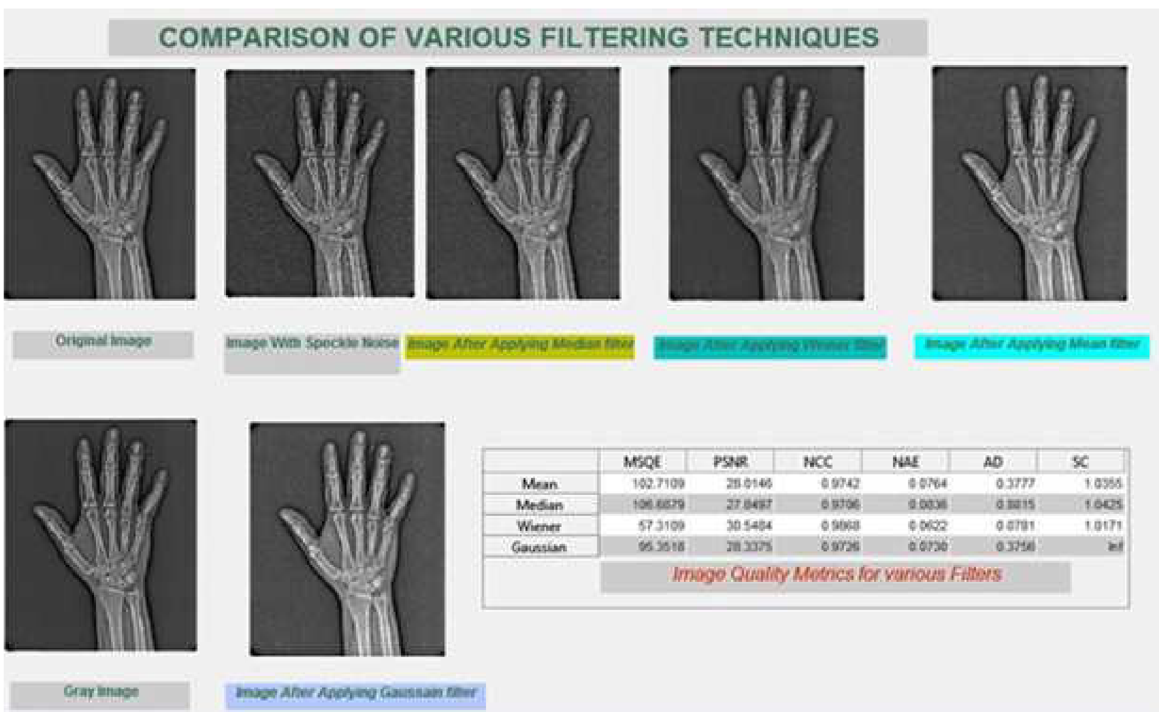

Figure 11
Screen shots for Speckle Noise

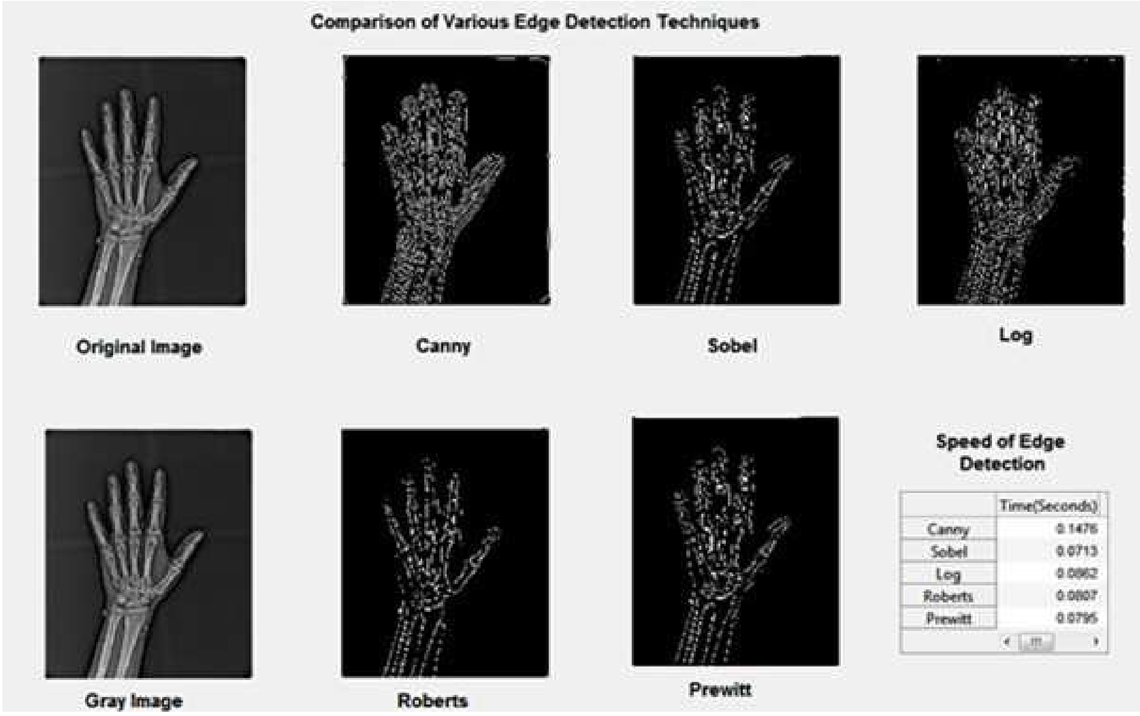

Figure 12
Screen shots for various edge detection algorithms

Figure 8 shows that implementation screen shots for various filters over Salt and Pepper noise, Figure 9 shows that implementation screen shots for various filters over Gaussian noise, Figure 10 shows that implementation screen shots for various filters over Poisson noise, Figure 11 shows that implementation screen shots for various filters over Speckle noise and performance of various filters displayed with image quality metrics. Figure 12 shows that implementation screen shots for various edge detection algorithms.

VII. CONCLUSION

In this work, Comparison of various edge detection algorithms is analyzed in terms of measuring speed of edge detection. From this it can be seen that canny algorithm is an efficient and effective algorithm to perform edge detection on digital x-ray images even though canny takes more time when compared with other algorithms. Canny algorithm is insensitive to noise and visual inspection is good. Comparisons of various filters over different type of noises are analyzed by measuring performance of parameters. From this it can be seen that median filter is best filter on digital x-ray images which gives an average performance over all types of noise.

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