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Removal of various Noises in Dental X-ray Images using Selective Median Filter

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Abstract: ***Image processing plays major role to provide additional information in medical diagnosis. Input images contain picture information as well as noise information. Noise information is added with the images during signal acquisition stage or in the transmission of image data. Salt & Pepper noise, Gaussian noise and Speckle noise is the major noises introduced in the images. Noise information may be interpreted as data and it may lead to severe problem. Linear and Non-linear filters are used to reduce these noises in the images. In medical image analysis, non-linear filters are preferred over linear filters because it preserves edge information. Dental X-ray image is used to identify the cavities and its depth. Average filter, median filter and wiener filter are the classical techniques used in many image processing applications. In this paper, three different noises (Salt &pepper, Gaussian and Speckle noise) are added and different filters (Average filters, median filter, Wiener filter) performances are analysed with the PSNR, SNR and MSE. Analysis shows that median filter is suitable for reducing salt & pepper noise and wiener filter is suitable for reducing Gaussian noise and speckle noise in the dental x-ray images. Selective median filter is a modified wiener filter. Median filter is used for the pixel value 0 and 255.For other pixel values wiener filter is used. Selective median filter is giving better result than traditional techniques.***

Keywords : Average filter, Dental X-ray image, Gaussian noise, median filter, Salt& pepper noise, Speckle noise, , wiener filter.

I. INTRODUCTION

Advancement in image processing algorithms leads to the invention in the field of robotics, medical imaging, biometrics, remote sensing, security and surveillance. In medical field, image processing algorithm helps the diagnostics to take the right decision in the complex cases. Particularly dental cavities and its depth are calculated using image processing algorithms. Image processing algorithms result purely depends on the quality of the images. However, digital images are unavoidably affected by noise due to acquisition, transmission and mathematical computation [1].

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Quality of the images degraded by the various noises added with it. In medical imaging poor illumination and acceptable radiation level causes degradation of specimens by increasing the noise influence. In medical imaging, retrieval of accurate information on data is important. If it is not interpreted in the accurate way it leads to fault result. It is used for the critical analysis. Noise often resembles as data and yield a problematic result. In recent days, Fusion techniques are used to identify the hidden problems in the medical image field. Fusion images are constructed by combining multiple model images. In this, noise in anyone of the image source lead to fault diagnosis. It totally affects the result and fail to diagnosis [2][3]. In[1] ,various reasons to introduce noises on CT,X-ray , PET,SPCET ,MRI and ultrasound images are discussed.

Variety of filters is proposed by the researchers for removing the different noises in the images. Most of the filters are application specific filters [4].They are salt and pepper noise, Gaussian noise, uniform and speckle noise. Salt & pepper noise is known as shot noise, impulse noise and spike noise. Random white and black pixels are added with the images. The intensity value of the pixel is going to be 255 or 0.Memory cell failure, camera sensor malfunction and image digitization errors are the some of the reason for the salt and pepper noise. Gaussian noise is introduced due to the random fluctuation in the signal. Pixel with random intensity is added with the image information. Sensor noises and electronic circuit noise are the sources of Gaussian noise. Speckle noise is introduced by multiplying the random value by pixel value. Uniform noise is introduced by quantization.

Image de-noising is the basic and essential process which reduces the noise present in the image and gives a component for other image processing techniques like segmentation and classification. Many de-noising algorithms are available. De-noising algorithms uses neighbouring pixel information to identify the noise and using the same information it corrects the error also. Algorithm filters the noise without degrading the image quality and helps to increase the visibility of the image taken for the examination. In [5], de-noising techniques are discussed and applied on MRI images. A modified simple edge preserved de-noising algorithm to remove salt and pepper noise in digital colour images is discussed in [6].Mean squared error (MSE) and peak signal-to-noise ratio (PSNR) have represented in the past years very popular measures for evaluating image processing algorithms. Nowadays, the PSNR is still a reference method [7-11], although other metrics have been shown to outperform PSNR in predicting the human perception of image quality although other metrics have been shown to outperform PSNR in predicting the human perception of image quality [12-14].

II. Experimental Methods

Filtering is the first module in most of the image processing algorithm. It is used to remove noises at the same time it preserves the details of the images. Filtering techniques is

classified into linear and non linear techniques. Linear filters provide good result on the images corrupted by salt & pepper noise and Gaussian noise. But the main drawback of the linear filtering technique is it tendency to blur the sharp edges and also destroys the fine details. In most of the medical imaging applications, non linear filtering is preferred over linear filtering. Non-linear filter preserves edges and also very effective to reduce impulsive noise. In this paper, median filter, average filter and wiener filter are reviewed by applying it on dental images and the methods are explained briefly.

A. Median Filter

Median filter is a traditional non linear filter used to reduce the amount of intensity change between adjacent pixels. Pixel and neighboring pixels are arranged in the ascending order. Median value is taken from the pixel and it is used to replace pixel value. This technique is best suitable to reduce the salt and pepper noise.

	30	90	60	
	40	70	25	
	63	32	45	

From the above figure pixel values are arranged as ascending order 25, 30, 32, 40, 45, 60, 63, 70, 90. In this pixel value 70 is replaced by median pixel value 45.

B. Wiener Filter

Wiener filter is used to remove the noise that degrades the signal quality. The filter is working on statistical analysis. Wiener filter is used to reduce the mean square error as much as possible. It is suitable to reduce the speckle noise and Gaussian noise. Spectral property of the noise and original signal is given by the equation

$$G(u,v) = \frac{H^*(u,v)}{|H(u,v)|^2 P_s(u,v) + P_n(u,v)} --(1)$$

Where

H*(u,v) is the fourier transform of the complex conjugate of the degraded function

Ps(u,v) is the fourier transform of the power spectral density of the non degraded image.

Pn(u,v) is the fourier transfoem of the power spectral density of the noise

H(u,v) is the degraded function

C. Average Filter

Average filter is the powerful linear filter. In this each pixel is replaced by the mean value of its neighbours, including itself. It is suitable to reduce the Gaussian noise. It is easy to design and also useful to reduce impulse noise. But it does not prevail the edges of the image.

Average of the pixels are calculated as (30, 90, 60, 40, 70, 25, 63, 32, 45)/9=51.Center pixel is replaced by the new pixel value 51 remaining pixels remains as it is.

	30	90	60	
	40	70	25	
	63	32	45	

III. Result and Discussion

Dental images are given as input. Salt & pepper noise, Gaussian noise and speckle noises are added with the input images at 10%, 20%, 30%, 40%,50% and 60% and its PSNR,SNR and MSE values are measured and drawn as graph. Pictorial information give us better idea on choosing the right filter based on PSNR, SNR and MSE.

A) Salt & Pepper Noise

Dental input image is added with the Salt & Pepper noise using the function imnoise in mat lab .Input image and noise added image is shown in figure 1.a and 1.b.Average filter is applied to the corrupted images using the matlab function filter2 (special) and it is shown in figure 1.c.Figure 1.d is the output after applying median filter using the mat lab function medfilt2().Wiener filter is applied to the corrupted image using the mat lab function wiener ( ) and corresponding output is shown in figure 1.e. Figure 1.f shows the output of proposed technique. PSNR, SNR and MSE values are calculated for the above said filters at different noise density as shown in table 1,2,3. Figure 2,3,4 represents the graphical representation of table values 1,2,3.In x axis noise density at 10%,20%30%,40%,50%,60% is considered and y axis PSNR ,SNR and MSE values are taken. From the graph, PSNR and SNR value is high and MSE value is low for median filter.

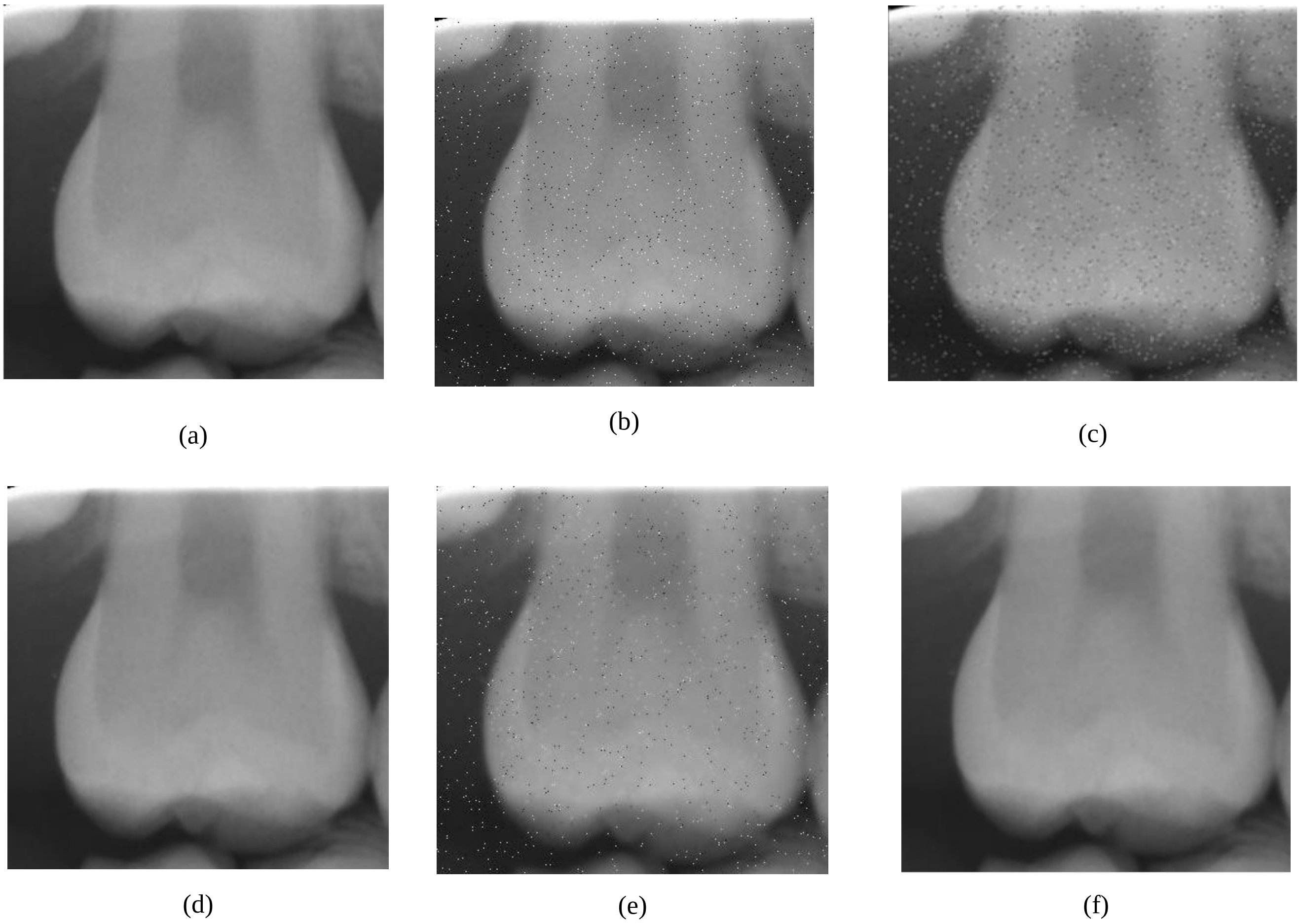

Figure 1: a) Input Image b) Salt & Pepper Noise-20% c) Average Filter output d) Median Filter output e) Weiner Filter output
f) Selective Median Filter

Table 1: PSNR Value at different Noise density

Noise density	PSNR in db				
	Before Filtering	Average Filter	Median Filter	Wiener Filter	Selective Median Filter
10%	25.380	30.965	46.302	28.166	49.975
20%	22.505	29.455	46.195	26.403	48.963
30%	20.848	28.290	42.563	25.627	45.459
40%	19.346	27.452	42.207	24.912	44.219
50%	18.466	26.6683	42.069	24.437	43.171
60%	17.698	26.084	41.0271	24.147	42.527

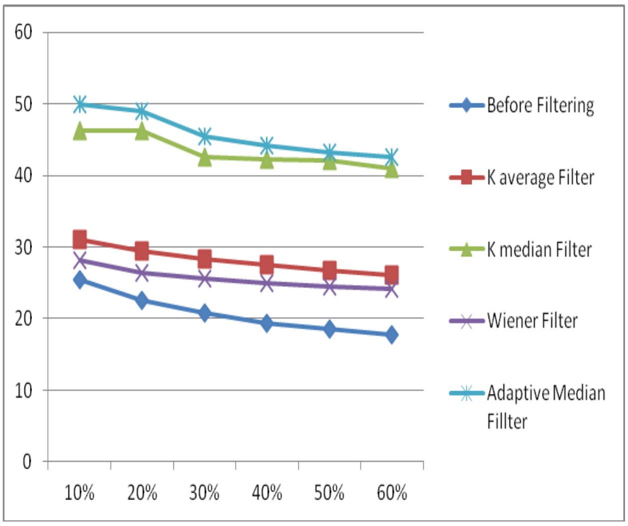

Figure 2: PSNR in db for different Filters

Table 2: SNR Value at different Noise density

Noise density	SNR in db				
	Before Filtering	Average Filter	Median Filter	Wiener Filter	Selective Median Filter
10%	25.3807	24.8189	40.1554	22.02	43.0965
20%	22.5052	23.3087	40.0486	20.26	42.9321
30%	20.8489	22.1436	36.4174	19.48	39.1325
40%	19.3463	21.3061	36.0604	18.77	38.9123
50%	18.4665	20.5217	35.9225	18.29	38.0126
60%	17.698	19.9379	34.8806	18.00	37.2389

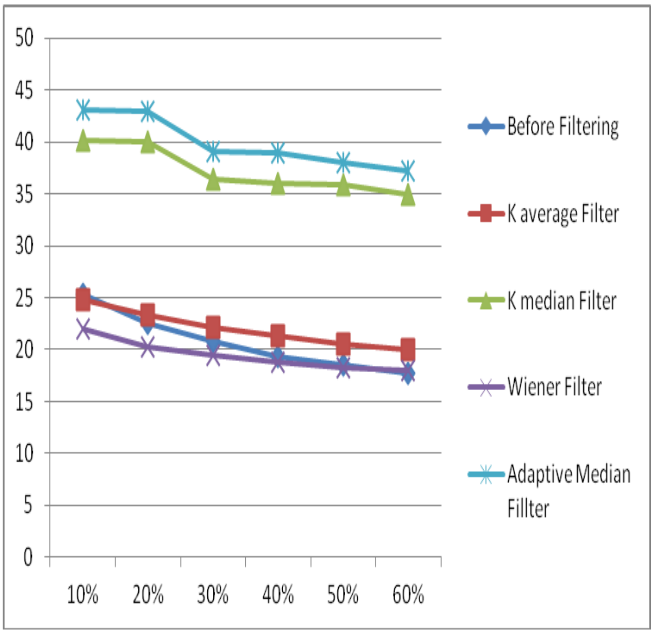

Figure 3: SNR in db for different Filters

Table 3 : MSE Value at different Noise density

Noise density	MSE				
	Before Filtering	Average Filter	Median Filter	Wiener Filter	Selective Median Filter
10%	0.0029	8.01E-04	2.34E-05	0.0015	2.14E-05
20%	0.0056	0.0012	2.40E-05	0.0023	2.26E-05
30%	0.0082	0.0015	5.54E-05	0.0027	5.21E-05
40%	0.0116	0.0018	6.02E-05	0.0032	5.93E-05
50%	0.0142	0.0022	6.21E-05	0.0036	6.18E-05
60%	0.017	0.0025	7.89E-05	0.0038	7.78E-05

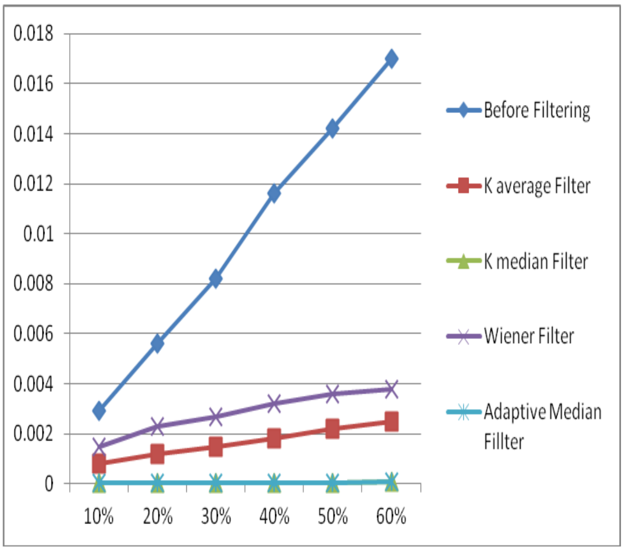

Figure 4: MSE for different Filters

B)Gaussian Noise

Dental input image is added with the Gaussian noise using the function imnoise in mat lab .Input image and noise added image is shown in figure 5.a and 5.b.Average filter is applied to the corrupted images using the mat lab function filter2 (special) and it is shown in figure5.c.Figure 5.d is the output after applying median filter using the mat lab function medfilt2() . Wiener filter is applied to the corrupted image using the mat lab function wiener () and corresponding output is shown in figure 5.e. Figure5.f shows the output of imfilterd image. PSNR, SNR and MSE values are calculated for the above said filters at different noise density as shown in table 4,5,6. Figure 6,7,8represents the graphical representation of table values 4,5,6.In x axis noise density at 10%,20%30%,40%,50%,60% is considered and y axis PSNR ,SNR and MSE values are taken. From the graph, PSNR and SNR value is high and MSE value is low for wiener filter. From this we can conclude that wiener filter is efficient to reduce the Gaussian noise.

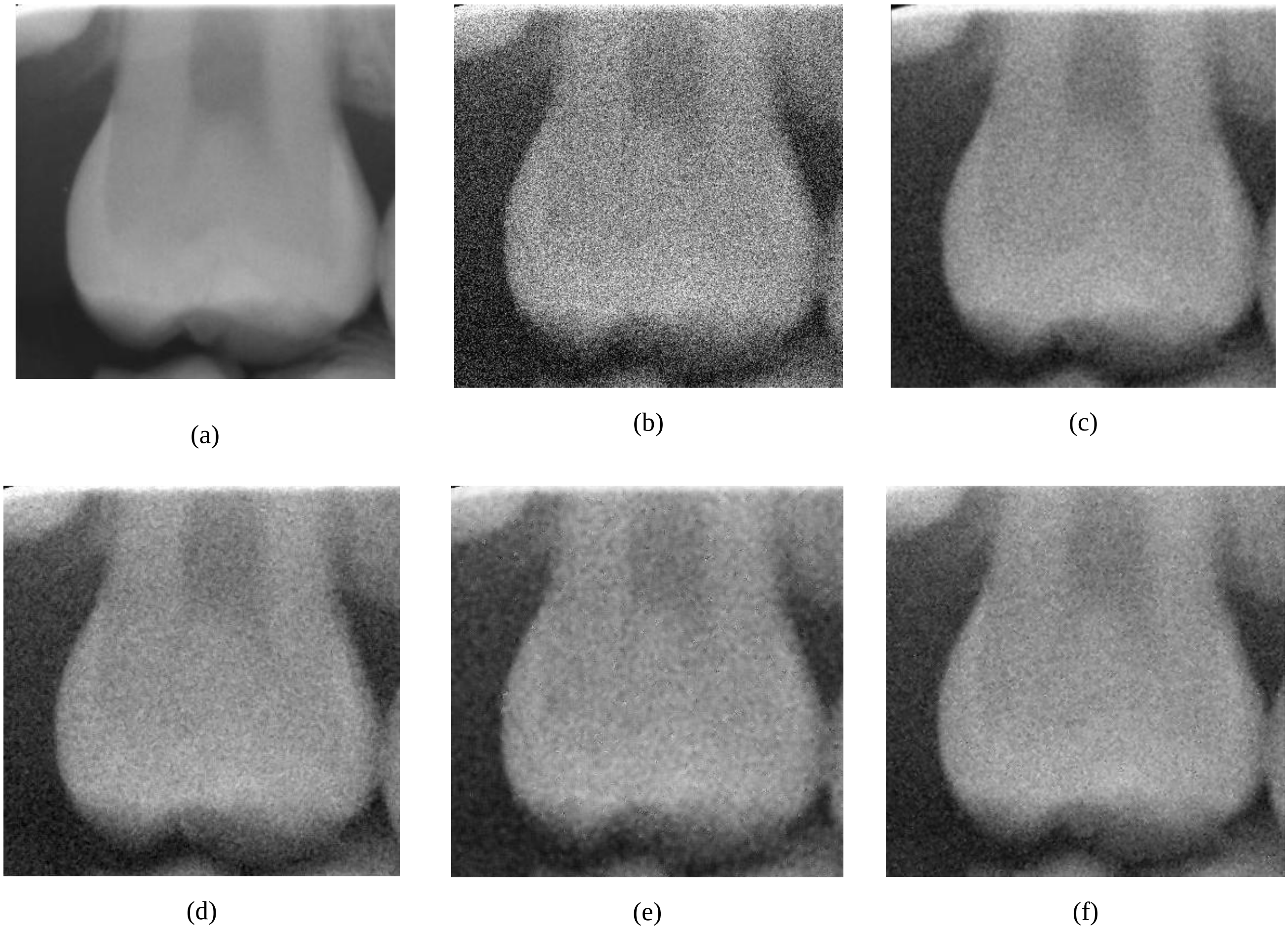

Figure 5: a) Input Image b) Gaussian Noise-20% c) Average Filter output d) Median Filter output e)Weiner Filter output f) Selective Median Filter output

Table 4 : PSNR Value at different Noise density

Noise density	PSNR in db				
	Before Filtering	Average Filter	Median Filter	Wiener Filter	Selective Median Filter
10%	20.1415	27.9453	27.5887	31.6735	33.145
20%	17.1891	25.7235	24.6898	28.3732	30.5483
30%	15.56	24.2826	22.8756	26.6914	29.1892
40%	14.467	23.2302	21.6745	25.3219	27.419
50%	13.6206	22.4467	20.7687	24.5206	26.7365
60%	12.9688	21.8392	19.94	23.8039	26.0184

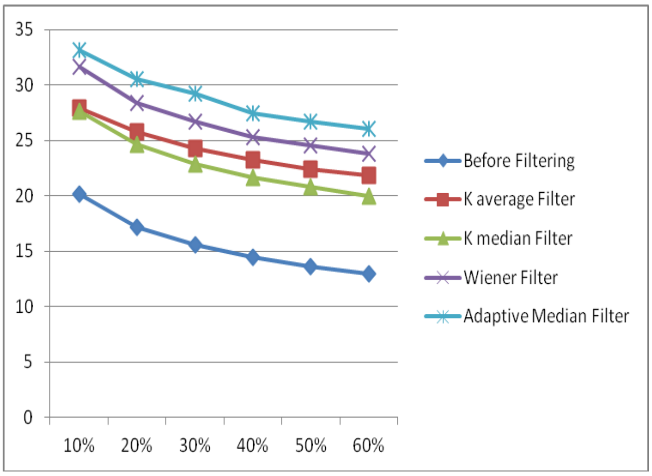

Figure 6: PSNR in db for different Filters

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Table 5: SNR Value at different Noise density

Noise density	SNR in db				
	Before Filtering	Average Filter	Median Filter	Wiener Filter	Selective Median Filter
10%	13.9949	21.798	21.4421	25.527	28.016
20%	11.0425	19.577	18.5432	22.226	24.986
30%	9.4215	18.136	16.7291	20.544	23.158
40%	8.3204	17.083	15.5279	19.175	21.847
50%	7.4740	16.300	14.6222	18.374	21.028
60%	6.8222	15.692	13.7934	17.657	20.147

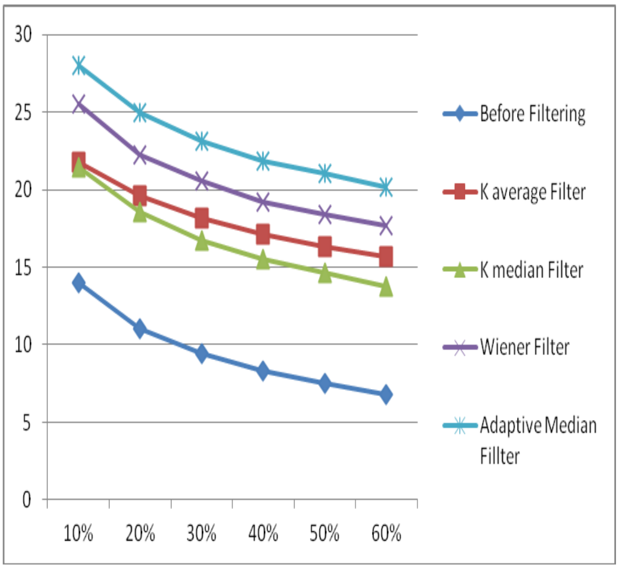

Figure 7: SNR in db for different Filters

Table 6 : MSE Value at different Noise density

Noise density	MSE				
	Before Filtering	Average Filter	Median Filter	Wiener Filter	Selective Median Filter
10%	0.0097	0.0016	0.0017	0.0006	0.00043
20%	0.0191	0.0027	0.0034	0.0015	0.0012
30%	0.0277	0.0037	0.0052	0.0021	0.0017
40%	0.0358	0.0048	0.0068	0.0029	0.0024
50%	0.0434	0.0057	0.0084	0.0035	0.0028
60%	0.0505	0.0065	0.0101	0.0042	0.0037

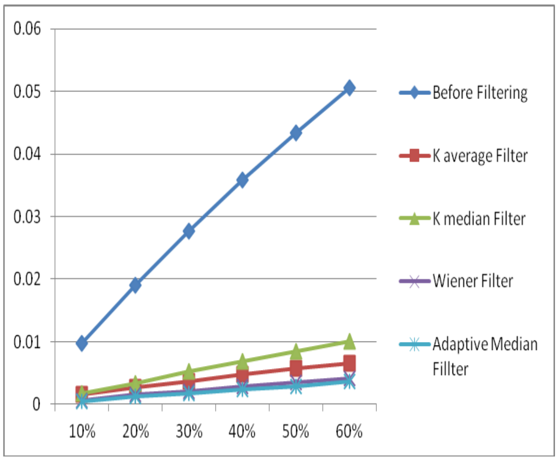

Figure 8: MSE for different Filters

C) Speckle Noise

Dental input image is added with the Speckle noise using the function imnoise in mat lab. Input image and noise added image is shown in figure 9.a and 9.b.Average filter is applied to the corrupted images using the mat lab function filter2 (special) and it is shown in figure9.c.Figure 9.d is the output after applying median filter using the mat lab function medfilt2(). Wiener filter is applied to the corrupted image using the mat lab function wiener ( ) and corresponding output is shown in figure 9.e. Figure 9.f shows the output of imfilterd image. PSNR, SNR and MSE values are calculated for the above said filters at different noise density as shown in table 7, 8, 9. Figure 10,11,12 represents the graphical representation of table values 7,8,9.In x axis noise density at 10%,20%30%,40%,50%,60% is considered and y axis PSNR ,SNR and MSE values are taken. From the graph, PSNR and SNR value is high and MSE value is low for wiener filter. From this we can conclude that wiener filter is efficient to reduce the Speckle noise.

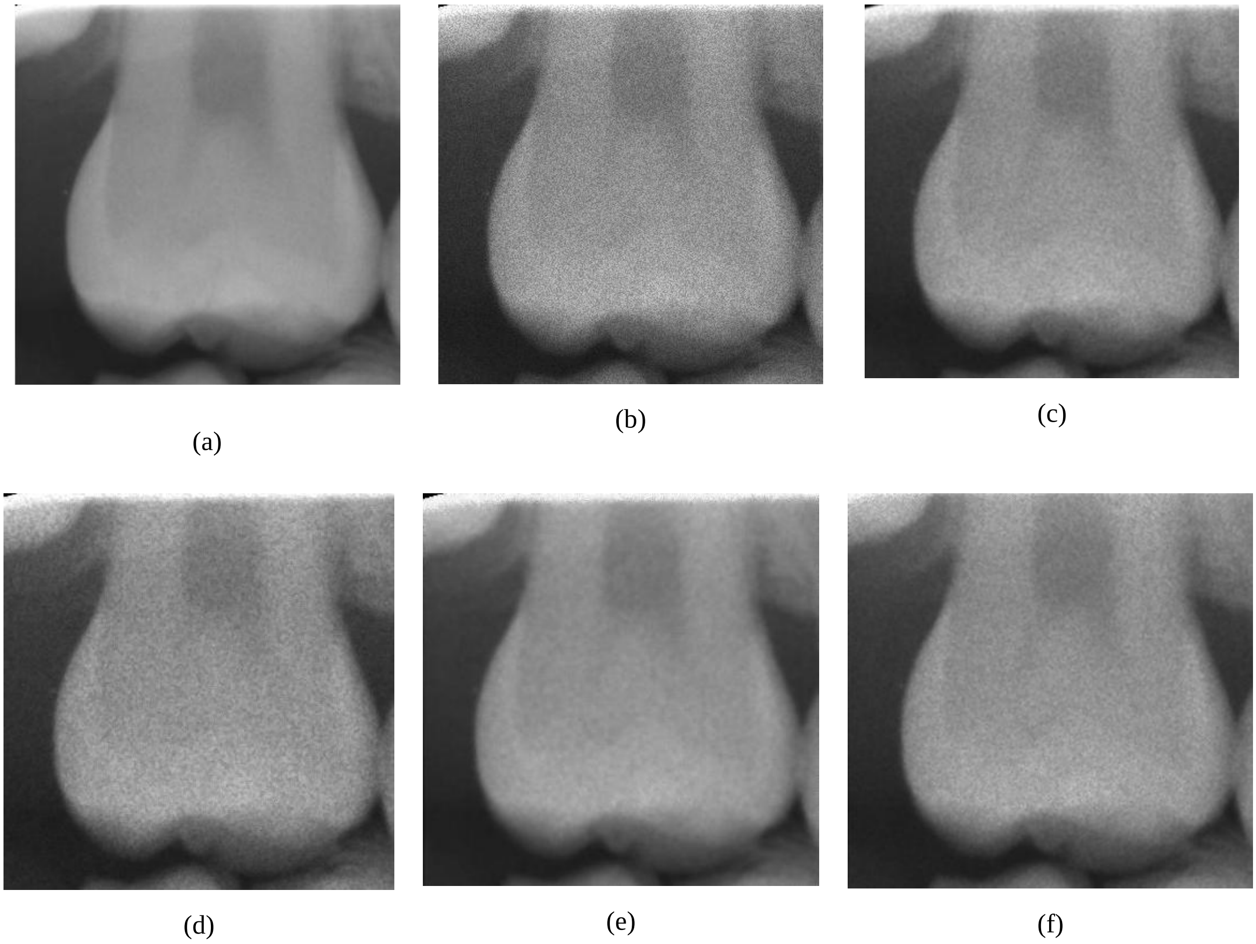

Figure 9: a) Input Image b) Speckle Noise-20% c) Average Filter output d) Median Filter output e) Weiner Filter output f) Selective Median Filter

Table 7 : PSNR Value at different Noise density

Noise density	PSNR in db				
	Before Filtering	Average Filter	Median Filter	Wiener Filter	Selective Median Filter
10%	26.2756	30.9713	31.6288	36.3295	37.3268
20%	23.2767	29.5998	28.6755	32.9235	34.0529
30%	21.4967	28.5895	26.9319	30.6822	32.8346
40%	20.2856	27.7711	25.6824	29.2422	31.3718
50%	19.3157	27.0226	24.698	28.0501	30.3509
60%	18.5431	26.4142	23.9825	27.0998	29.2558

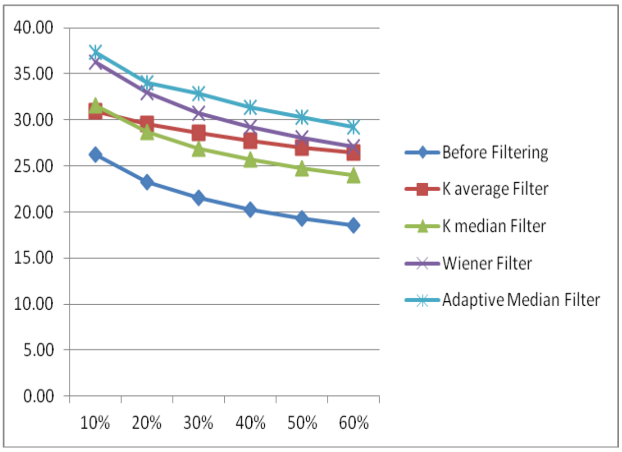

Figure 10: PSNR in db for different Filters

Table 8 : SNR Value at different Noise density

Noise density	SNR in db				
	Before Filtering	Average Filter	Median Filter	Wiener Filter	Selective Median Filter
10%	20.129	24.8248	25.4822	30.183	32.3452
20%	17.1302	23.4532	22.529	26.7769	29.3249
30%	15.3501	22.443	20.7854	24.5356	26.2378
40%	14.139	21.6245	19.5358	23.0956	24.9876
50%	13.1692	20.876	18.5515	21.9035	23.4534
60%	12.3965	20.2676	17.836	20.9533	23.3688

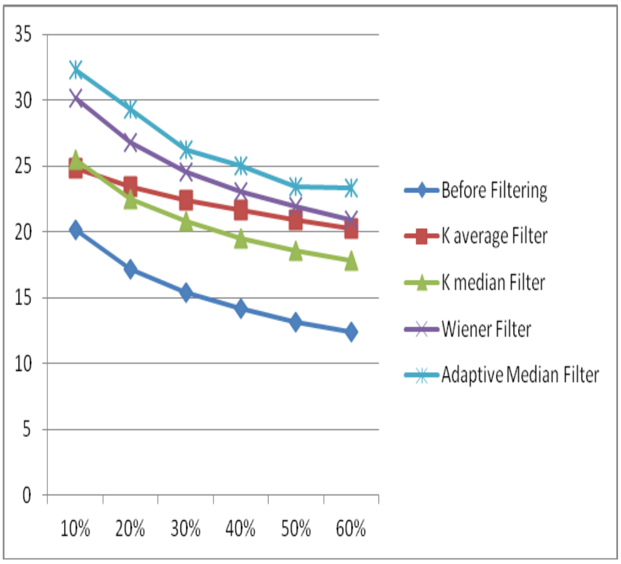

Figure 11: SNR in db for different Filters

Table 9: MSE Value at different Noise density

Noise density	MSE				
	Before Filtering	Average Filter	Median Filter	Wiener Filter	Selective Median Filter
10%	0.0024	8.00E-04	6.87E-04	2.33E-04	0.000164
20%	0.0047	0.0011	0.0014	5.10E-04	0.000398
30%	0.0071	0.0014	0.002	8.55E-04	0.000714
40%	0.0094	0.0017	0.0027	0.0012	0.000912
50%	0.0117	0.002	0.0034	0.0016	0.001148
60%	0.014	0.0023	0.004	0.0019	0.001568

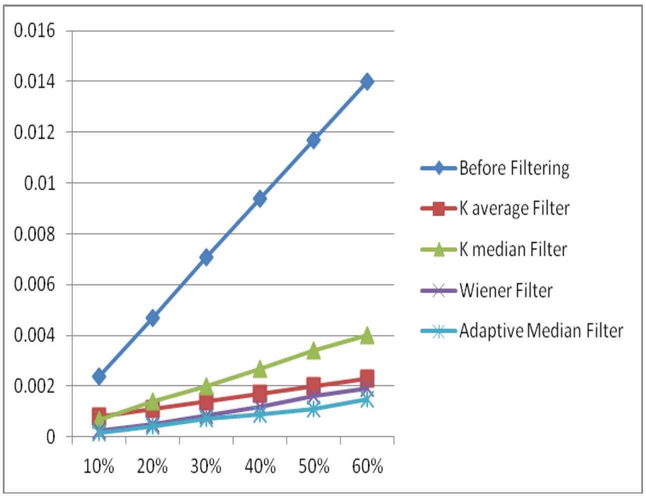

Figure 12: MSE for different Filters

IV. CONCLUSION

The analysis is performed to identify the suitable pre-processing techniques for dental images. Salt and Pepper noise, speckle noise and Gaussian noises are added with the input images at different intensities. Median filter, Average filter, linear filter and wiener filter is applied on the corrupted images and their corresponding PSNR, SNR and MSE values are analyzed using the graph . Graph shows that median filter is suitable for Salt & Pepper noise and Wiener filter is suitable for Speckle noise and Gaussian noise. The above analysis gave an idea to design a selective median filter. Proposed selective median filter acts as a median filter for salt & pepper noise. Selective median filter is acts as wiener filter for speckle noise and Gaussian noise. PSNR, SNR and MSE values are taken by adding salt & pepper noise, speckle noise and Gaussian noise at different percentage. Graph shows that proposed selective median filter is working well for different noise. PSNR and SNR value is high and MSE value is low for selective median filter compared to traditional filter. Selective median filter technique can be applied on the corrupted dental images in the preprocessing stage. In future this work will be utilized by the researchers on various medical imaging applications.

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