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The Performance Analysis of Median Filter for Suppressing Impulse Noise from Images

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Abstract: *The impulse noise suppression is a challenging task in digital image processing. In this paper, the median filtering is applied to low, medium and high detail images that are corrupted by low to high density impulse noise. The performance of a median filter is evaluated based on edge preserving capabilities, subjective and objective analysis. The simulation results indicate that the median filter preserves edges in all the categories of images.*
Keywords: *Image Processing, Impulse Noise, Salt & Pepper Noise, Mean and Median Filtering.*

I. Introduction

The image restoration is the process of filtering the observed image in order to minimize the effect of degradation. The image restoration techniques are broadly classified into linear and non-linear filtering. The linear filter is simple in operation and suppresses additive Gaussian noise effectively. The performance of a linear filter is found to be unsatisfactory for the restoration of images corrupted by impulse noise. The linear filter has the tendency of blurring the edges and modifies the step edges to ramp edge. The examples of linear filter are average filter [1], geometric mean filter[1], and harmonic mean filter[1] .

The non linear filters are also called as ordered statistics filter. The most popular and oldest non linear filter is median filter proposed by Tukey in 1971[2]. The median filter is immensely popular for attenuating impulse from images. The utility of median filter in image processing application are as follows

1. The median filter is employed to suppress impulse noise in MRI, cancer, X-ray and brain image [3]. It is found that, the performance of median filter is good for MRI image, better for brain image and best for cancer and X-ray image.
2. The median filter is applied to suppress different types of noise in microscopy image [4].
3. The rank order based adaptive median filter (RAMF) and impulse size based adaptive median filter (SAMF) is proposed in [5] to suppress impulse noise from images. The former is superior to non linear mean L in suppressing positive and negative impulses and the later is superior than Lin's adaptive filter in suppressing high density impulse noise.
4. The median filter controlled by fuzzy rules was proposed in order to remove impulse noise in images [6].
5. The use of median filter within a Bayesian frame work leads to a development of global methods for image smoothing [7].
6. Ozen and others in [8] showed that median filter can be used in finger print recognition algorithm.
7. The median filter can be used for reducing interpolation error and improving the quality of 3D image in a free hand 3D ultrasound system [9].
8. Zhouping used median filtering approach for noise attenuation in X-ray microscopy image [10].

Based on the extensive survey it has been observed that none of the researcher has applied median filter to attenuate impulse noise in low, medium and high detail image. Further it is observed that the edge preserving aspect of median filter is not yet demonstrated experimentally. In this paper, the median filter is applied to suppress impulse noise in low, medium and high detail image and the edge preserving ability of a median filter is demonstrated.

II. Image Restoration Techniques

The image restoration is an objective area of image processing which deals with the minimization of degradation from an image. The degradation can be either blur or noise. In this work the efforts are made towards minimization of noise from images. The image restoration is generally employed by performing filtering operation on images and defined mathematically as

$$y=L(x) \quad (1)$$

Where x is input image, y is output image and 'L' is an operation performed on input image. The restoration filters are as follows

1. Mean Filter.
2. Geometric and Harmonic Mean Filter.
3. Median Filter.

2.1. Mean Filter

The mean filter replaces each pixel in the corrupted image by mean value of the pixels in the filtering window of area A_{xy}. The mean filtering is expressed according to equation 2

$$g(x,y)= 1/mn \sum_{(r,s)\in Axy} f(x+r, y+s) \qquad (2)$$

2.2. Geometric Mean Filter

The response of the geometric mean filter is the geometric mean of the pixels in the filtering window of area A_{xy} and defined according to equation 3.

$$g(x,y)=[\prod f(x+r, y+s)]\hat{}(1/mn) \qquad (3)$$

2.3. Harmonic Mean Filter

The harmonic mean filtering operation is given by the expression

$$g(x,y)=\frac{mn}{\sum_{(r,s)\in Axy}\left(\frac{1}{f(x+r,y+s)}\right)} \qquad (4)$$

2.4. Median Filter

Median filter is a non linear method used for the removal of impulse noise. The median filtering is accomplished by moving a mask over the image and calculating its response at each stage by ordering the pixels in the filtering window. The median filter replaces each pixel by median value of data within the filtering window. The median filtering is illustrated in algorithm presented in figure1.

Consider a set of identically distributed random variable x_i, where i ε {1,2,3….n}. If the random variables are arranged in an ascending or descending order of magnitude such that $x_{(1)}<x_{(2)}<x_{(3)}<x_{(4)}<x_{(5)}<x_{(6)} \ldots\ldots\ldots <x_{(n)}$

$$Y=\text{median}\{ x_{(1)}<x_{(2)}<x_{(3)}<x_{(4)}<x_{(5)}<x_{(6)} \ldots\ldots\ldots <x_{(n)}\} \qquad (5)$$

```
for( i=1:M)
for(j=1:N)
B(1:3,1:3)=O(i-1:i+1,j-1:j+1)
Y(i,j)=med(B(:))
end
end
```

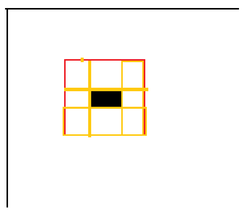


Figure 1: Median Filtering

III. Results and discussion

In this experiment, the low, medium and high detail images are considered for the performance evaluation of median filter. The images are categorized into low, medium and high detail based on edge pixels. The low, medium and high detail image respectively comprises less, medium and large number of edges in the image. The test image that belongs to low, medium and high detail is cameraman, guide-scolar and shivakumar swamiji image respectively.

All the three category of test images are corrupted with fixed valued salt & pepper impulses, where the corrupted pixel takes on the values of either 0 or 255 with equal probability.The effectiveness of the median filtering is evaluated based on

1. Edge Preserving Capabilities.
2. Subjective Analysis.
3. Objective Analysis.

To demonstrate the edge preserving capabilities of a median filter, the edges are detected in the restored images and compared with that of original images using Sobel edge detector. The performance of a median filter based on subjective analysis is evaluated through visual quality of a restored images which are shown in figure 2,3,4 and 5.

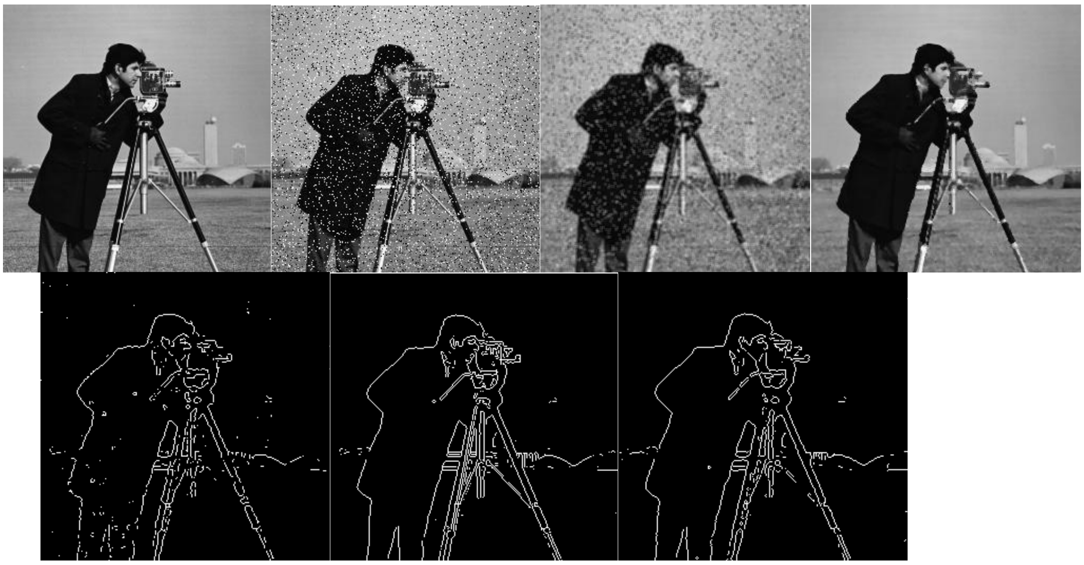
In objective analysis, the performance of a median filter is evaluated by calculating mean square error (MAE), peak signal to noise ratio (PSNR) and mean absolute error (MAE). The MSE, PSNR and MAE are defined according to the following formulae

$$MSE(x,z) = \frac{1}{N \times N} \sum_{i,j}^{N} \left(x(i,j) - z(i,j) \right)^2 \tag{6}$$

$$PSNR(x,z) = 10 * \log_{10} \left(\frac{255 * 255}{MSE(x,z)} \right) \tag{7}$$

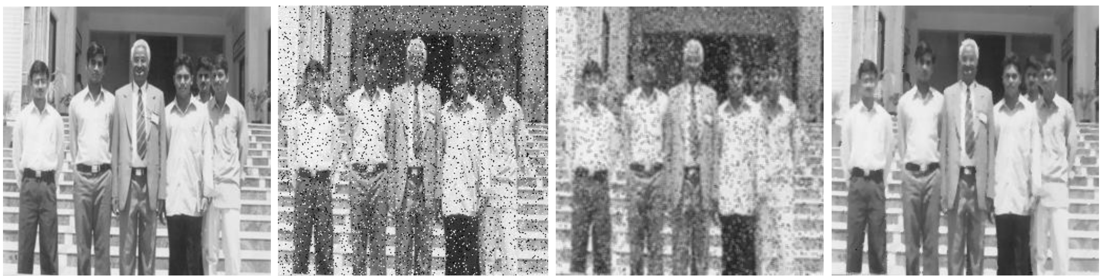
$$MAE(x,z) = \frac{1}{N \times N} \sum_{i,j}^{N} \left| \left(x(i,j) - z(i,j) \right) \right| \tag{8}$$

Where $z_{i,j}$ and x_{ij} denotes the pixel values of the restored image and the original image respectively. N x N is the size of the image. Since it is not possible to show all the visual results of the experiment, the restoration results are shown in figure 2, 3 and 4 for low, medium and high detail image corrupted by 10% impulse noise. The visual results show that the median filter preserves edges and suppresses low density impulse noise effectively at the cost of blurring the edges. The comparisons of mean square error (MSE), mean absolute error (MAE) and peak signal to noise ratio (PSNR) for low, medium & high detail noisy and restored image using mean and median filters are shown in figure 5,6,and7 respectively. The subjective and objective results of the experiment illustrates that the median filter outperforms than mean filter for low density impulse noise.



a	b	c	d
e	f	g	

Figure 2 a) Low detail image. b) Image corrupted by 10% impulse noise. c-d) Image restored using mean and median filter.e) Edges in original image Using Sobel edge detector . f-g)Edges in restored image using mean and median filter.

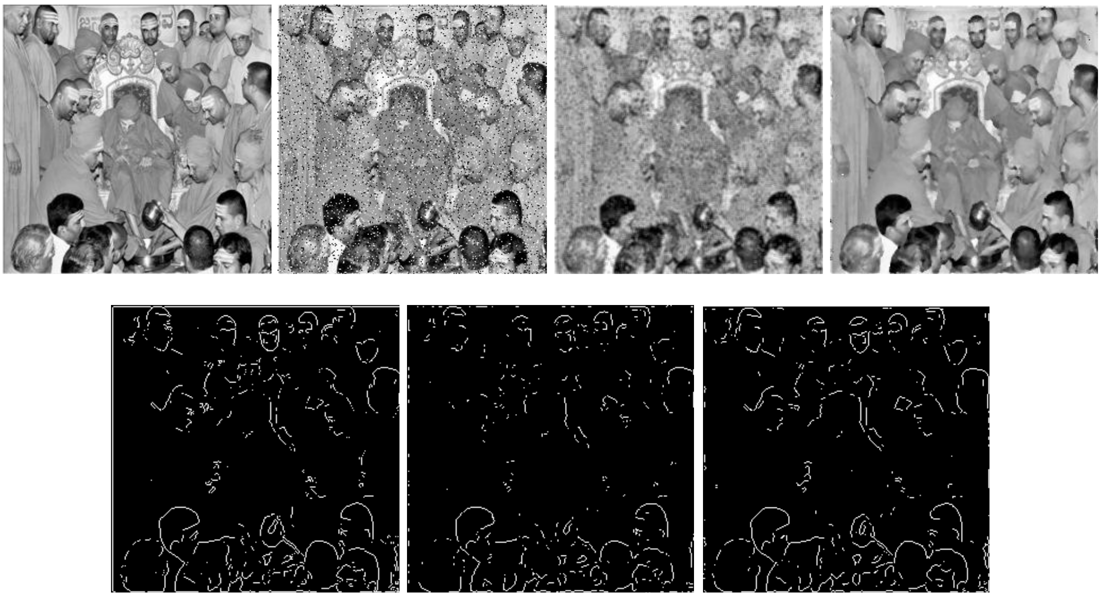


a	b	c	d

Figure 3 a) Medium detail image. b) Image corrupted by 10% impulse noise. c-d) Image restored using mean and median filter.

e	f	g

Figure 3 e) Edges in original image Using Sobel edge detector . f-g)Edges in restored image using mean and median filter.



a	b	c	d
e	f	g	

Figure 4 a) High detail image. b) Image corrupted by 10% impulse noise. c-d) Image restored using mean and median filter. e) Edges in original image Using Sobel edge detector . f-g)Edges in restored image using mean and median filter.

Table 1: Comparisons on restoration results in terms of MSE, PSNR and MAE for low detail image.

Noise Density	MSE			PSNR			MAE		
	Noisy and Origin Image	Mean	Median	Noisy and Original Image	Mean	Median	Noisy and Original Image	Mean	Median
1%	203.18	186	122	24.84	25.41	27.25	1.32	7.11	4.20
2%	404.86	213	124	22.22	24.83	27.18	2.48	8.05	4.25
3%	593.86	240	129	20.25	24.31	27	3.86	8.97	4.33
4%	813.93	263	131	18.81	23.92	26.94	5.34	9.70	4.38
5%	1014.9	290	134	18.08	23.5	26.85	6.34	10.49	4.43
6%	1262.8	321	137	17.36	23.05	26.74	7.56	11.38	4.48
7%	1390.3	346	141	16.62	22.73	26.62	8.91	12.04	4.54
8%	1581.3	376	145	16.09	22.37	26.49	10.14	12.84	4.63
9%	1815.6	398	150	15.55	22.13	26.35	11.34	13.37	4.68
10%	2024.7	437	148	15.17	21.72	26.40	12.57	14.28	4.69
15%	3021	586	189	13.2	20.44	25.34	19.31	17.40	5.14
20%	4009	763	228	12.1	19.3	24.53	25.3	20.40	5.57
25%	5070	962	326	11.08	18.29	22.99	31.79	23.39	6.38
30%	5992	1180	463	10.35	17.4	21.47	37.9	26.16	7.38
40%	8070	1695	1037	9.06	15.83	17.97	50.93	31.81	11.31
50%	10094	2142	2231	8.09	14.82	14.64	63.58	36.24	18.89
60%	12156	2782	4489	7.28	13.68	11.6	76.68	41.64	32.6

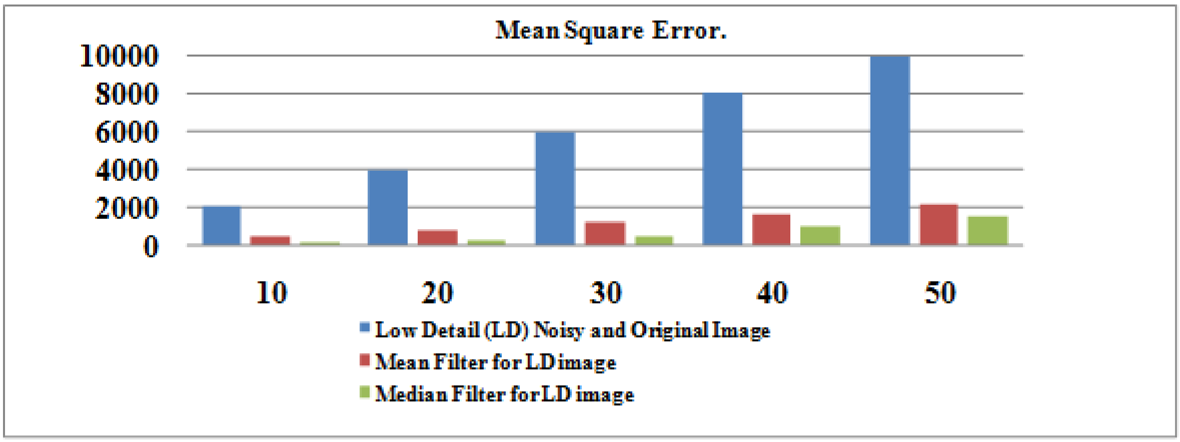


Figure 5: MSE performance evaluation of mean and median filtering the low detail image corrupted by impulse noise at various noise densities.

Table 2: Comparisons on restoration results in terms of MSE, PSNR and MAE for medium detail image.

Noise Density	MSE			PSNR			MAE		
	Noisy and Original Image	Mean	Median	Noisy and Original Image	Mean	Median	Noisy and Original Image	Mean	Median
1%	194	108	51	25.24	27.79	31	1.22	6.47	3.12
4%	806	186	56	19.06	25.41	30.59	5.06	9.03	3.32
5%	1057	217	58	17.88	24.75	30.46	6.53	9.89	3.39
8%	1640	297	67	15.98	23.39	29.85	10.16	12.07	3.62
10%	2052	364	72	15	22.51	29.51	12.69	13.54	3.79
15%	3054	518	105	13.28	20.98	27.88	19.08	16.74	4.32
20%	4111	699	141	11.99	19.68	26.62	25.56	19.94	4.88
25%	5144	930	241	11.017	18.44	24.30	32.11	23.37	5.84
30%	6172	1119	399	10.22	17.64	22.11	38.43	25.88	7.17
40%	8173	1597	996	9	16.09	18.14	51.04	31.37	11.46
50%	10182	2210	2237	8.05	14.68	14.63	63.55	37.34	19.35
60%	12094	2788	4078	7.3	13.67	12.02	75.74	42.26	31

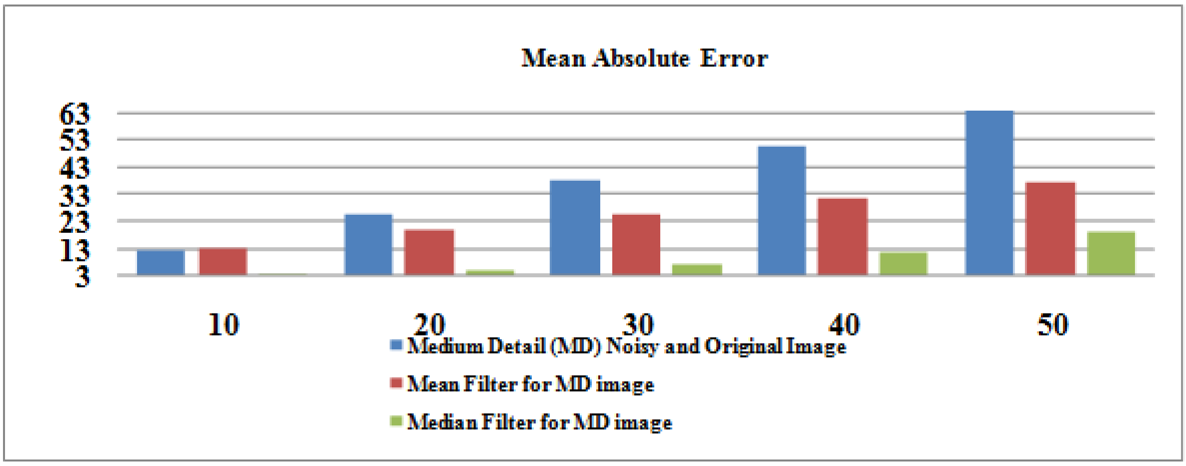


Figure 6: MAE performance evaluation of mean and median filtering the medium detail image corrupted by impulse noise at various noise densities.

Noise Density	MSE			PSNR			MAE		
	Noisy and Original Image	Mean	Median	Noisy and Original Image	Mean	Median	Noisy and Original Image	Mean	Median
1%	187	211	138	25.39	24.87	26.71	1.22	9.67	6.26
4%	774	291	150	19.24	23.49	26.34	5.09	11.87	6.55
5%	952	317	151	18.34	23.11	26.31	6.35	12.57	6.6
8%	1521	395	166	16.3	22.15	25.90	10.04	14.36	6.92
10%	1883	462	179	15.38	21.48	25.59	12.46	15.73	7.13
15%	2903	592	233	13.5	20.40	24.63	19.08	18.27	7.81
20%	3884	769	281	12.23	19.27	23.63	25.58	20.95	8.58
25%	4883	930	392	11.24	18.44	22.19	32.17	23.30	9.60
30%	5805	1114	532	10.49	17.66	20.16	38.36	25.71	10.91
40%	7802	1522	1213	9.2	16.30	17.29	51.34	30.32	15.74
50%	9582	1979	1314	8.3	15.16	14.48	63.37	34.80	23.21
60%	11468	2420	1516	7.5	14.29	11.94	75.91	38.71	35.01

Table 3: Comparisons on restoration results in terms of MSE, PSNR and MAE for high detail image.

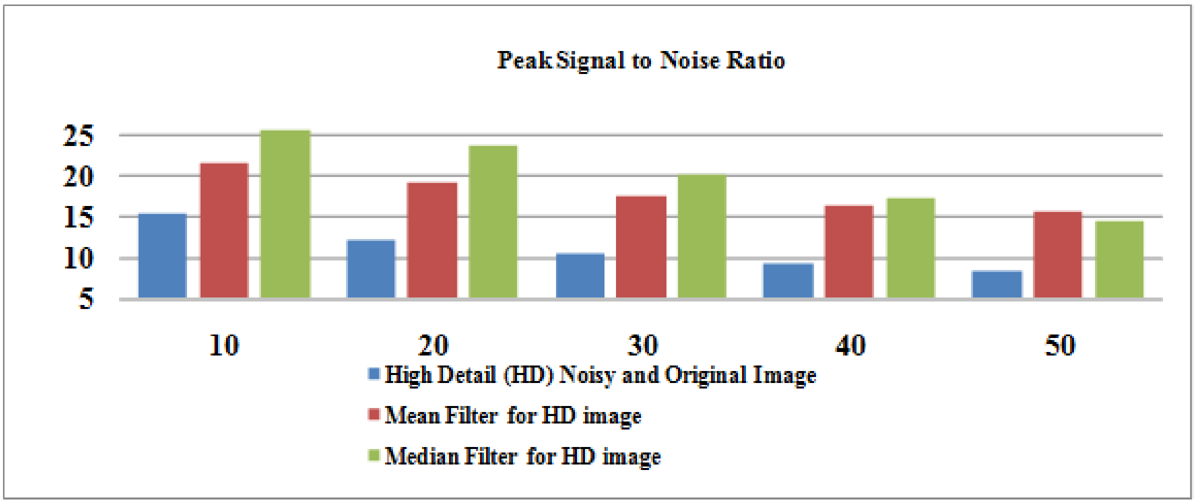


Figure 7: PSNR performance evaluation of mean and median filtering the high detail image corrupted by impulse noise at various noise densities.

IV. Conclusions

In this work the performance of median filter is studied experimentally. The potential of the median filter is evaluated through edge detection capabilities, subjective and objective analysis. In order to draw the safer conclusion the median filtering is applied for wide range of images which are corrupted by different levels of noise density. From the experimental analysis we conclude the following

1. The performance of the median filtering is found to be much satisfactory for low density impulse noise.
2. The median filter performs uniform filtering. Therefore some of the uncorrupted pixels are modified which is the undesirable feature of median filtering.
3. By observing the edge maps of restored images, we found that some of the edge pixels are modified due the nature of uniform filtering. The modification of edges due to filtering is disagreeable when the performance is evaluated based on subjective analysis.
4. Further the honest conclusion is that an effort can be made to improve the performance of a median filter by performing filtering action only on non edge noisy pixels.

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References

[1]. R.C.Gonzalez and R.E.Woods Digital Image Processing, second edition, Pearson Education 2002.
[2]. J.W.Tukey “Nonlinear Methods for Smoothing Data” Jn Congr Rec.EASCON,1974.
[3]. Bhausahed Shinde,Dynandeo Mhaske,A.R.Dani “Study of Noise Detection and Removal Techniques in Medical Images”, IJIGSP Vol 2, page no 51-60, March 2012.

[4]. Pawan Patidar, Manoj Gupta, Sumit Srivastav, Ashok Kumar Nagawat," Image Denoising by various Filters for different noise "International Journal of Computer Applications,vol 9,no 4, November 2010.

[5]. H.Hwang and R.A.Haddad,"Adaptive Median Filters:New Algorithms and Results",IEEE transactions on Image Processing, vol 4,no 4,April 1995.

[6]. Kaoru Arakawa,"Median Filter based on Fuzzy rules and its application to image restoration" Fuzzy Sets and systems, vol 77, Issue 1, 15 January 1996, pages 3-13.

[7]. Giovanni Sebastiani, Sebastiano Stramaglia "A Bayesian Approach for median Filter in Image Processing", Signal Processing,vol 62,Issue 3,November 1997,pages 303-309.

[8]. Ayyuce M, Kizrak, Figen Ozen,"A New Median Filter based Finger Print Recognition Algorithm" Procedia Computer Science, Vol 3, 2011, pages 859-865.

[9]. Qing-Hua Huang, Yong-Ping Zheng, "Volume Reconstruction of Free Hand 3D Ultrasound using Median Filter" Ultrsonics,vol48.Issue 3, July 2008, pages 182-192.

[10]. Zhouping Wei, Jian Wang,Helen Nichol, Sheldon wiabe, Dean Chapan,"A Median-Guassian Filtering Frame Work for Moire Pattern Noise Removal from X-ray microscopy image ",Micron vol 43,issues 2-3,February 2012,pages 17 0-176.

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