APPLYING NON-LINEAR FILTERS TO IMAGE WITH DIFFERENT TYPES OF NOISES AND ANALYSING THEM

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1 Introduction

Image pixels get damaged with noises that occur due to transmission errors, malfunctioning pixel elements in the camera sensors, faulty memory locations, and timing errors in analog-to-digital conversion. Our aim is to compare removal of various types of noises along with standard averaging filters and a hybrid median filter. We will be demonstrating that hybrid median filter provides best filtering for taken images. For all window filters there is some problem. That is edge treating. If you place window over an element at the edge, some part of the window will be empty. To fill the gap, signal should be extended. For this purpose, we have to perform various pre-processing operations to extend the image.

2 Theoretical Background

Noise reduction is the process of removing noise from a signal. All signal processing devices, both analog and digital, have traits that make them susceptible to noise. Noise can be random or white noise with an even frequency distribution, or frequency dependent noise introduced by a device's mechanism or signal processing algorithms. In electronic recording devices, a major type of noise is hiss created by random electron motion due to thermal agitation at all temperatures above absolute zero. These agitated electrons rapidly add and subtract from the voltage of the output signal and thus create detectable noise. In the case of photographic film and magnetic tape, noise (both visible and audible) is introduced due to the grain structure of the medium. In photographic film, the size of the grains in the film determines the film's sensitivity, more sensitive film having larger sized grains. In magnetic tape, the larger the grains of the magnetic particles (usually ferric oxide or magnetite), the more prone the medium is to noise.Images taken with both digital cameras and conventional film cameras will pick up noise from a variety of sources. Further use of these images will often require that the noise be (partially) removed – for aesthetic purposes as in artistic work or marketing, or for practical purposes such as computer vision.

3 Motivation

In selecting a noise reduction algorithm, one must weigh several factors like the available computer power and time available, a digital camera must apply noise reduction in a fraction of a second using a tiny onboard CPU, while a desktop computer has much more power and time whether sacrificing some real detail is acceptable if it allows more noise to be removed (how aggressively to decide whether variations in the image are noise or not) the characteristics of the noise and the detail in the image, to better make those decisions. Image filters produce a new image from an original by operating on the pixel values. Filters are used to suppress noise, enhance contrast, find edges, and locate features. If we want to enhance the quality of images, we can use various filtering techniques which are available in image processing. There are various filters which can remove the noise from images and preserve image details and enhance the quality of image. The common noise which contains the image is impulse noise. The impulse noise is salt and pepper noise (image having the random black and white dots). Mean filter not perfect for remove impulse noise. Impulse noise can be removed by order statistics filter. The median filter is the filter removes most of the noise in image. But there is advanced filter called hybrid median filter which preserves corner with removal of impulse noise.

4 Aim of Proposed Work

We intend to design filter is windowed filter of nonlinear class that easily removes impulse noise while preserving edges. In comparison with basic version of the median filter hybrid one has better corner preserving characteristics. The basic idea behind filter is for any elements of the signal (image) apply median technique several times varying window shape and then take the median of the got median values. The hybrid median filter takes two medians: in an “X” and in a “+” centered on the pixel. The output is the median of these two medians and the original pixel value. Motivation: preserves corners

5 Objective of Proposed Work

We will be designing a hybrid median filter and comparing it to existing nonlinear filters for impulse noise, poisson noise and gaussian noise. We will use parameters like PSNR, MSE, SSI to compare the results among the 3 non- linear filters. We are using 5 test images for comparison.

6 Literature Survey

2.1. Survey of the Existing Models/Work

Paper [1]: Removing Gaussian noise

This gives an algorithm that initially calculates the amount of noise from the image. In the second stage, the centre pixel is replaced by the mean value of the some of the surrounding pixels based on a threshold value. Noise removal with edge preservation and computational complexity are two conflicting parameters. The proposed method is a solution for these requirements. The performance of the algorithm is tested and compared with standard mean filter, wiener filter, alpha trimmed mean filter K- means filter, bilateral filter and recently proposed trilateral filter. Experimental results show the superior performance of the proposed filtering algorithm compared to the other standard algorithms in terms of both subjective and objective evaluations

Reference: V.R. Vijaykumar, P.T. Vanathi, P. Kanagasabapathy," Fast and Efficient Algorithm to Remove Gaussian Noise in Digital Images". International Journal of Computer Science, 37:1, IJCS$_3$7$_{10}$9

Paper [2]: Removing Poisson (Shot) noise

This paper uses the method of regulating the variation of pixel intensities to reduce Poisson noise. This new model uses total variation regularization which also preserves edges. The result of this method is that the strength of the regularization is signal independent which is same as Poisson noise. This model preserves low contrast features in regions of low intensity.

Reference: Triet Le, Rick Chartrand, Thomas J. Asaki, "A Variational Approach to Reconstructing Images Corrupted by Poisson Noise", Journal of Mathematical Imaging and Vision (2007) 27: 257

Paper [3]: Removing Salt and Pepper (Impulse) noise

This paper discusses various techniques to remove salt and pepper noise. This paper illustrates some of the common averaging filters that we have learned in the curriculum. After Mean filter the modified Mean-Median is introduced as a new filter which is used to remove the efficient noise from the image. To overcome the Mean-Median filter the SMF is used for removing impulse noise. SUMF is used to remove high density salt pepper noise from digital images. WMF removes the discontinuity in underlying regression function whereas the Decision Based Filter is efficient to de-noise the low level, it fails in medium and high density because the restored pixel which is the median value of the selected window is also a corrupted pixel value. To overcome this problem the new weighted median filter was introduced which gives satisfactory result in reducing high level salt and pepper noise.

Reference: Deepalakshmi R, Sindhuja A, "Survey on Salt and Pepper Noise Removal Techniques", International Journal of Innovative Research in Science, Engineering and Technology (2017) 6:11

7 Summary/Gaps identified in the Survey

For all window filters there is some problem. That is edge treating. If you place window over an element at the edge, some part of the window will be empty. To fill the gap, signal should be extended. For hybrid median filter there is good idea to extend image symmetrically. In other words we are adding lines at the top and at the bottom of the image and add columns to the left and to the right of it. A hybrid median filter has the advantage of preserving corners and other features that are eliminated by the 3 x 3 and 5 x 5 median filters. With repeated application, the hybrid median filter does not excessively smooth image details (as do the conventional median filters), and typically provides superior visual quality in the filtered image. One advantage of the hybrid median filter is due to its adaptive nature, which allows the filter to perform better than the standard median filter on fast-moving picture information of small spatial extent.

8 Overview of the Proposed System

Hybrid median filter This is another type of the non filter and advanced version of the median filter. The impulse noise removing is greatly improved by hybrid median filter. Here the median value of X, + shaped neighbours can be calculated and median value of that these are added to original median value.

9 Framework, Architecture or Module for the Proposed System

B = hmf (A, n) performs hybrid median filtering of the matrix A using an n x n box. Hybrid median filter preserves edges better than a square kernel (neighboring pixels) median filter because it is a three-step ranking operation: data from different spatial directions are ranked separately. Three median values are calculated: MR is the median of horizontal and vertical R pixels, and MD is the median of diagonal D pixels. The filtered value is the median of the two median values and the central pixel C: median ([MR, MD, C]). As an example, for n = 5:

10 Proposed System Model

Algorithm for Hybrid median filter: 1. Place a cross-window over element; 2. Pick up elements; 3. Order elements; 4. Take the middle element; 5. Place a +-window over element; 6. Pick up elements; 7. Order elements; 8. Take the middle element; 9. Pick up result in point 4, 8 and element itself; 10. Order elements; 11. Take the middle element.

$$\begin{bmatrix} D & * & R & * & D \\ * & D & R & D & * \\ R & R & D\,C\,R & R & R \\ * & D & R & D & * \\ D & * & R & * & D \end{bmatrix}$$

Figure 1: Y = median of MR, MD, C

11 Proposed System Analysis and Design

Test images

Test Image analysis:

Salt Pepper Noise

The mean-squared error of the noisy image is 936.2835 The PSNR ratio of the noisy image is 18.4167

Using Mean Filter

The mean-squared error of the image filtered by averaging filter is 201.2010 The PSNR ratio of the image filtered by averaging filter is 25.0945

Using Median Filter

The mean-squared error of the image filtered by median filter is 32.5255 The PSNR ratio of the image filtered by median filter is 33.0086

Using Hybrid Median Filter:

The mean-squared error of the image filtered by hybrid median filter is 4.0293 The PSNR ratio of the image filtered by hybrid median filter is 42.0785

Gaussian Noise:

The mean-squared error of the noisy image is 642.2840 The PSNR ratio of the noisy image is 20.0535

Using Mean Filter

The mean-squared error of the image filtered by mean filter is 157.3335 The PSNR ratio of the image filtered by mean filter is 26.1626

Using Median Filter The mean-squared error of the image filtered by median filter is 150.5339 The PSNR ratio of the image filtered by median filter is 26.3545

Using Hybrid Median Filter The mean-squared error of the image filtered by hybrid median filter is 4.0293 The PSNR ratio of the image filtered by hybrid median filter is 42.0785

Poisson Noise The mean-squared error of the noisy image is 138.2266 The

PSNR ratio of the noisy image is 26.7249

Using Mean Filter The mean-squared error of the image filtered by mean filter is 101.1527 The PSNR ratio of the image filtered by averaging filter is 28.0810

Using Median Filter The mean-squared error of the image filtered by median filter is 53.2964 The PSNR ratio of the image filtered by median filter is 30.8638

Using Hybrid Median Filter The mean-squared error of the image filtered by hybrid median filter is 4.0293 The PSNR ratio of the image filtered by hybrid median filter is 42.0785

Comparison Table

12 Results and Discussion

After successfully applying the filters to the images with different types of noises, we have found the MSE and PSNR for all the results and have tabulated them as shown in the table. As seen from the table, for all types of noises, MSE value of the hybrid median filter comes to be the lowest which means the error is least. At the same time, the Peak Signal to Noise Ratio is the highest. This result suggests that Hybrid Median Filter comes out to be the best for all the cases. Analyzing for other filters, in case of Salt and Pepper, median filter is better than mean filter. In case of Gaussian noise, both mean and median filter gives almost the same result though median is slightly better than mean. For Poisson noise, again the median filter comes out to be better than the mean filter.

13 Conclusion

In this paper the main aim is to remove the impulse noise from the image by using the hybrid median filter. The impulse noise can be removed efficiently and smooth the all noise other than impulse noise. The hybrid median filters have some of the advantages in image processing. For repeated application the hybrid median filter does not excessively smooth image details, Edge treating is possible, Hybrid median filter preserves edges better than a median filter, Preserves brightness difference., Simple to understand The HMF has some disadvantages also in IP. It is only helpful to remove only impulse noise; it is non linear filter, High computation cost. So in order to avoid that disadvantages the new filters are discovered.

14 Code

I=imread ('barbara.jpg'); IB = imnoise (I,'salt pepper'); figure(1) subplot(1,2,1) subimage(I) title('Original Image') subplot(1, 2, 2) subimage(IB) title ('Noisy Image')

N=ones(3)/9; If1=imfilter(IB, N); figure(2) image(If1) title('Noisy image filtered by a 3-by-3 averaging filter')

$\text{img}_m ed = IB; for c = 1:3 img_m ed(:,:,c) = medfilt2(IB(:,:,c),[3,3]); end figure(3) image(img_m ed) title('N$
$by-3 median filter')$

$\text{img}_h med = hmf(I,3); figure(4); image(img_h med) title('Noisy Image filtered by a 3-$
$by-3 hybrid median filter')$

fprintf('*********ERROR COMPARISON********')

$\text{err}_I B = immse(I,IB); fprintf('mean-squared error of the noisy image is err2_I B =$
$psnr(I,IB); fprintf('The PSNR ratio of the noisy image is err3_I B = ssim(IB,I); fprintf('The SSIM of the no$

$\text{err}_I f1 = immse(I,If1); fprintf('mean-squared error of the image filtered by averaging filter is err2_I f1 =$
$psnr(I,If1); fprintf('The PSNR ratio of the image filtered by averaging filter is err3_I f1 =$
$ssim(If1,I); fprintf('The SSIM of image filtered by averaging filter is$

$\text{err}_i mg_m ed = immse(I,img_m ed); fprintf('mean-squared error of the image filtered by median filter is err2_i$
$psnr(I,img_m ed); fprintf('The PSNR ratio of the image filtered by median filter is err3_i mg_m ed =$
$ssim(I,img_m ed); fprintf('The SSIM of image filtered by median filter is$

$\text{err}_i mg_h med = immse(I,img_h med); fprintf('mean-squared error of the image filtered by hybrid median fil$
$psnr(I,img_h med); fprintf('The PSNR ratio of the image filtered by hybrid median filter is err3_i mg_h med =$
$ssim(I,img_h med); fprintf('The SSIM of image filtered by hybrid median filter is$

References

1. : V.R.Vijaykumar, P.T.Vanathi, P.Kanagasabapathy," Fast and Efficient Algorithm to Remove Gaussian Noise in Digital Images". International Journal of Computer Science, 37:1, $\text{IJCS}_37_10 9$

$2. Triet Le, Rick Chartrand, Thomas J. Asaki, \backslash A Variational Approach to Reconstructing Images Corrupted by P$
257

$3. Deepalakshmi R, Sindhuja A, \backslash Survey on Salt and Pepper Noise Removal Techniques", International Journal$
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Figure 2: Test

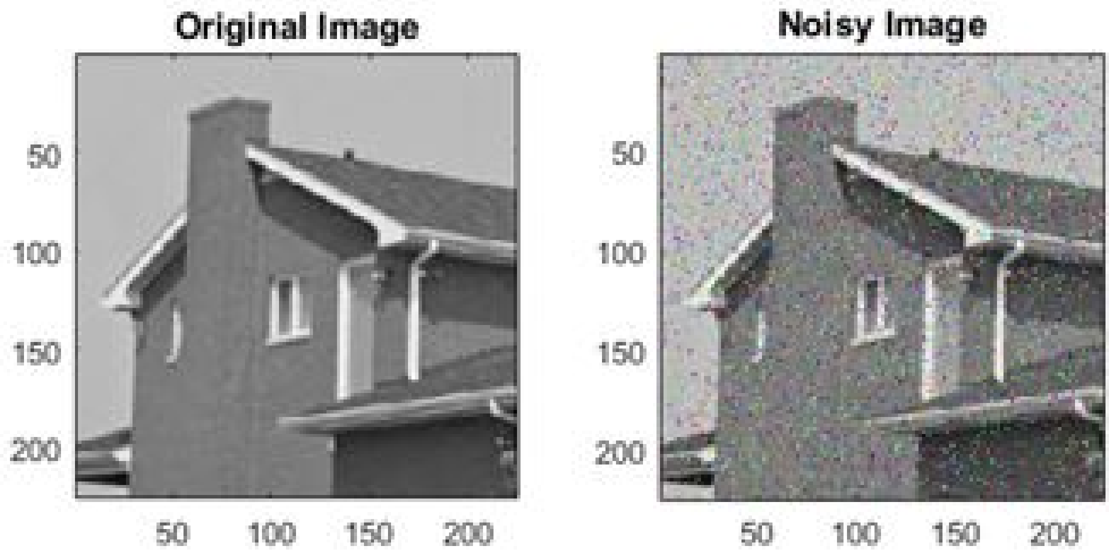

Figure 3: Y = median of MR, MD, C

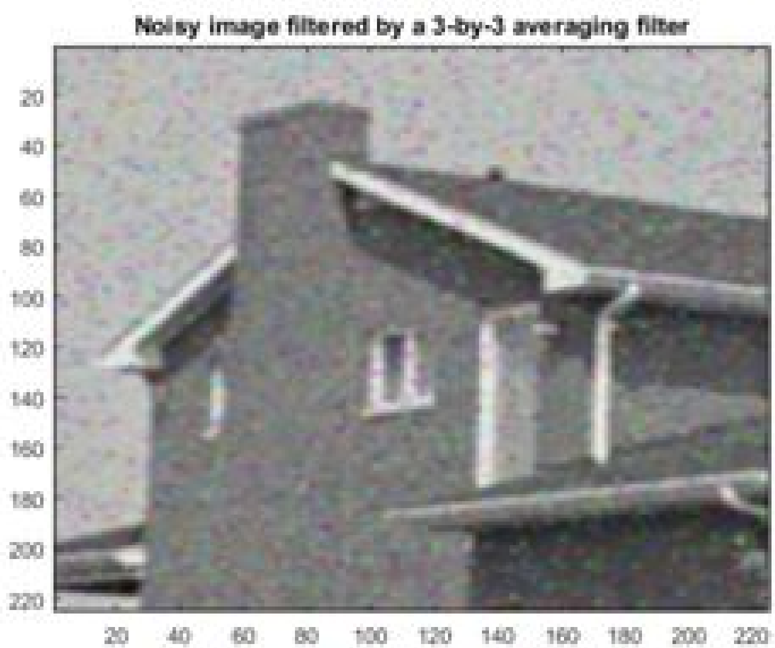

Figure 4: Y = median of MR, MD, C

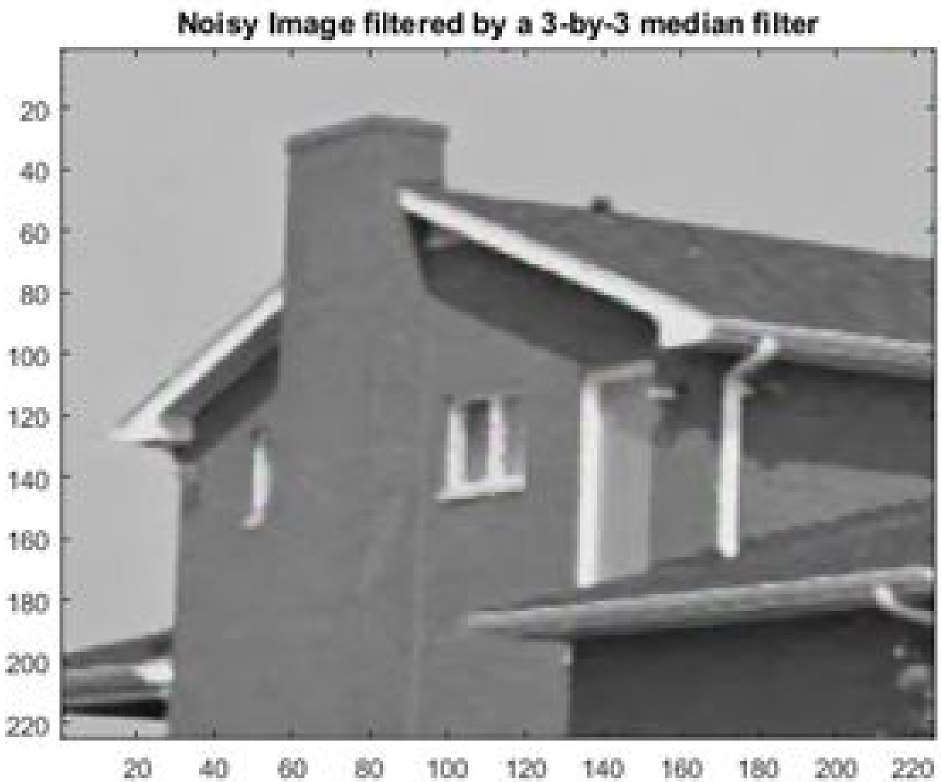

Figure 5: Y = median of MR, MD, C

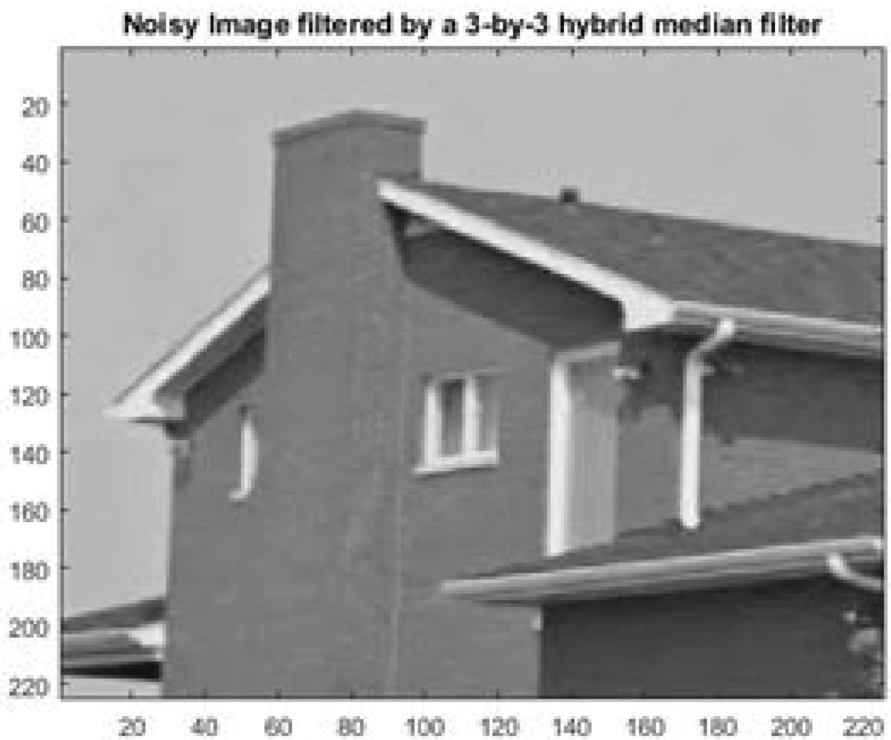

Figure 6: Y = median of MR, MD, C

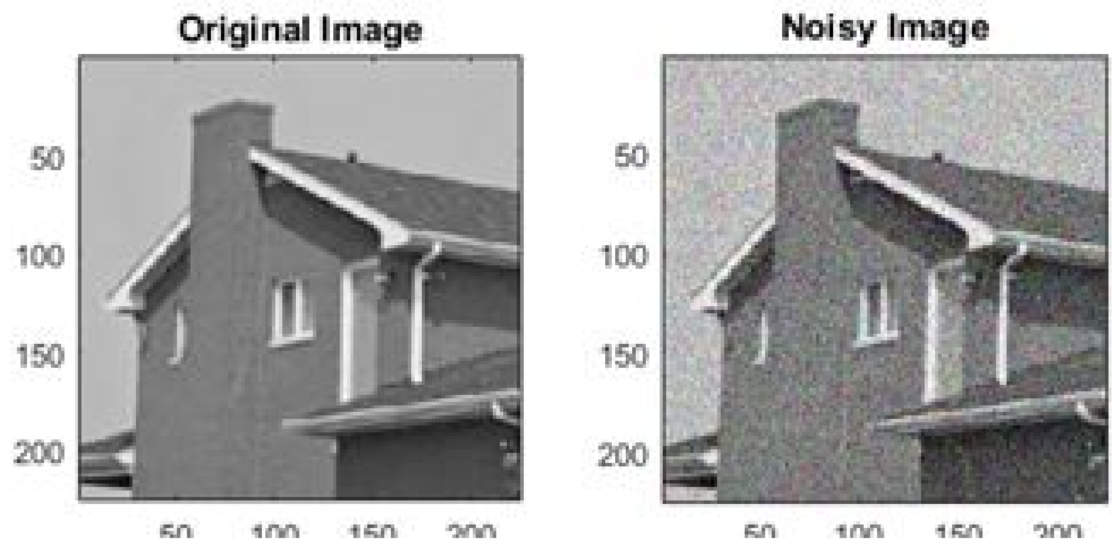

Figure 7: Y = median of MR, MD, C

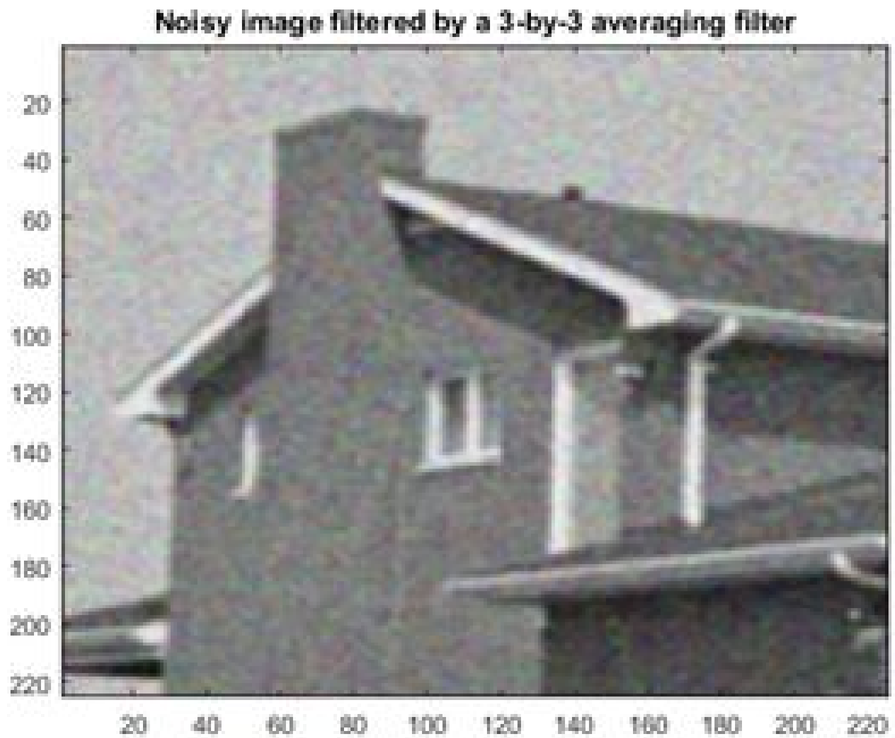

Figure 8: Y = median of MR, MD, C

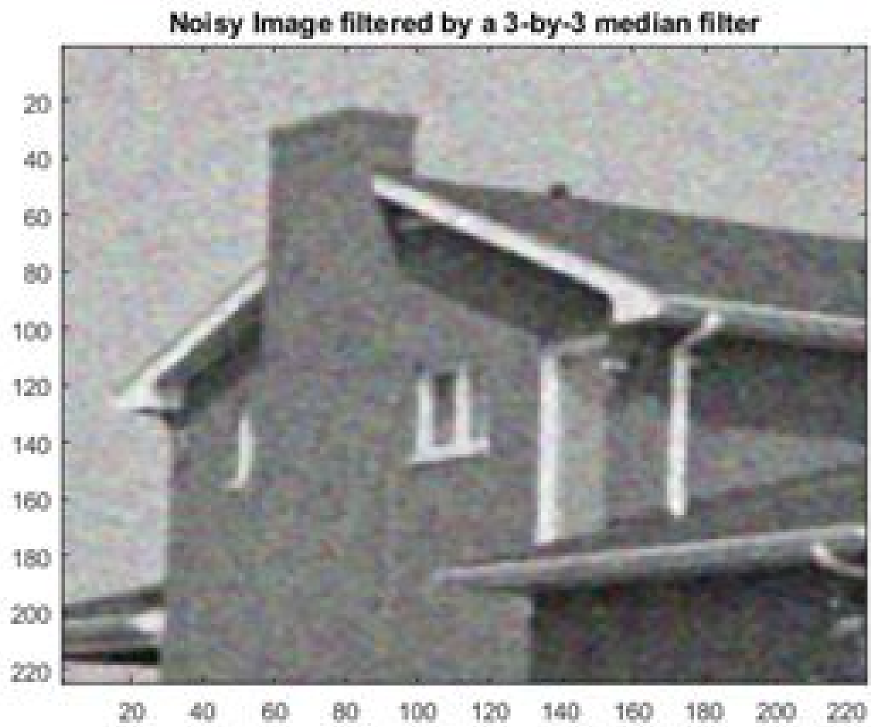

Figure 9: Y = median of MR, MD, C

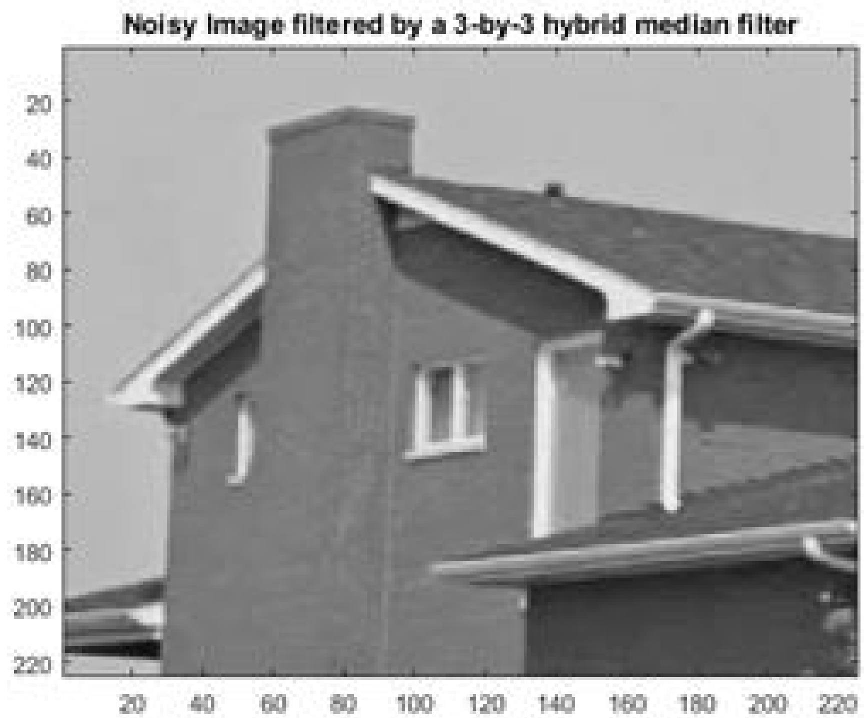

Figure 10: Y = median of MR, MD, C

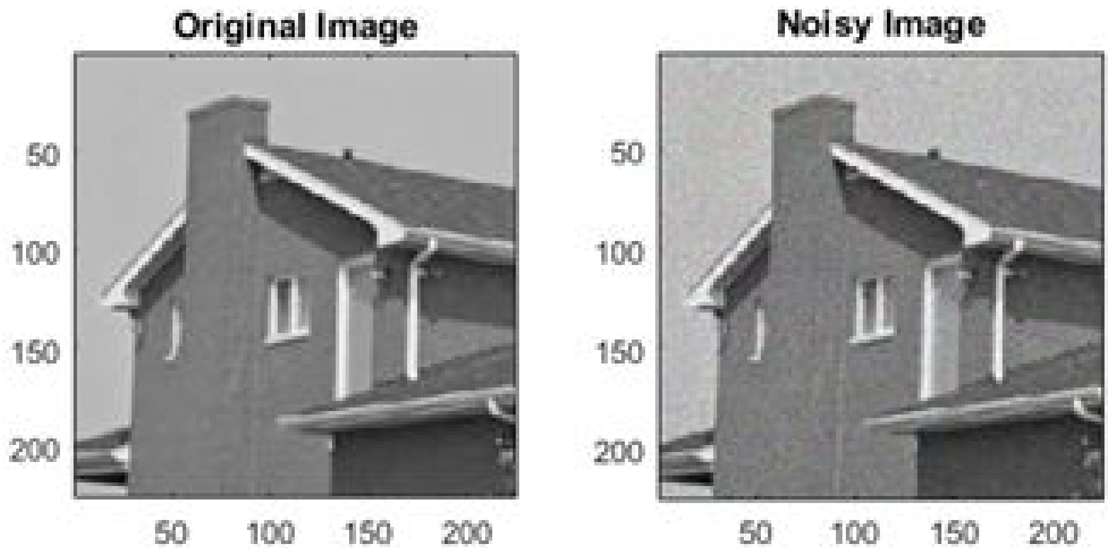

Figure 11: Y = median of MR, MD, C

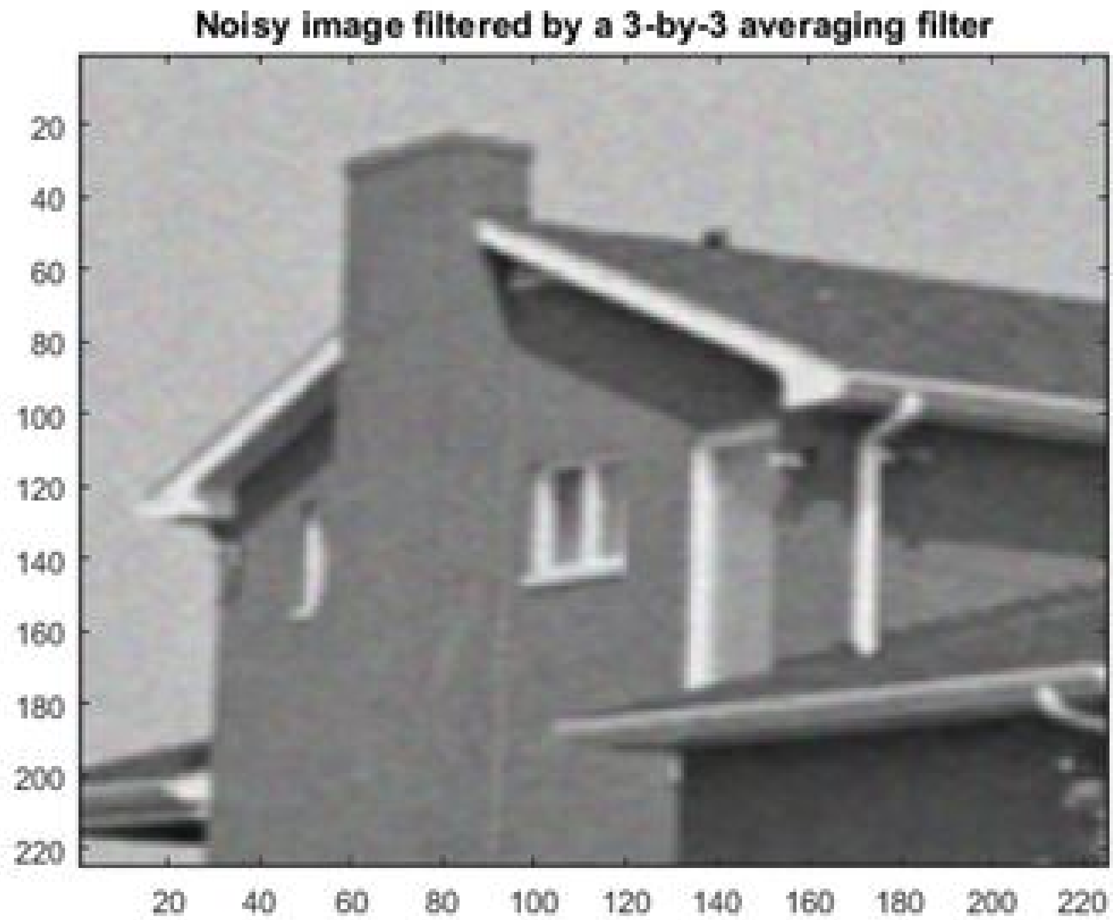

Figure 12: Y = median of MR, MD, C

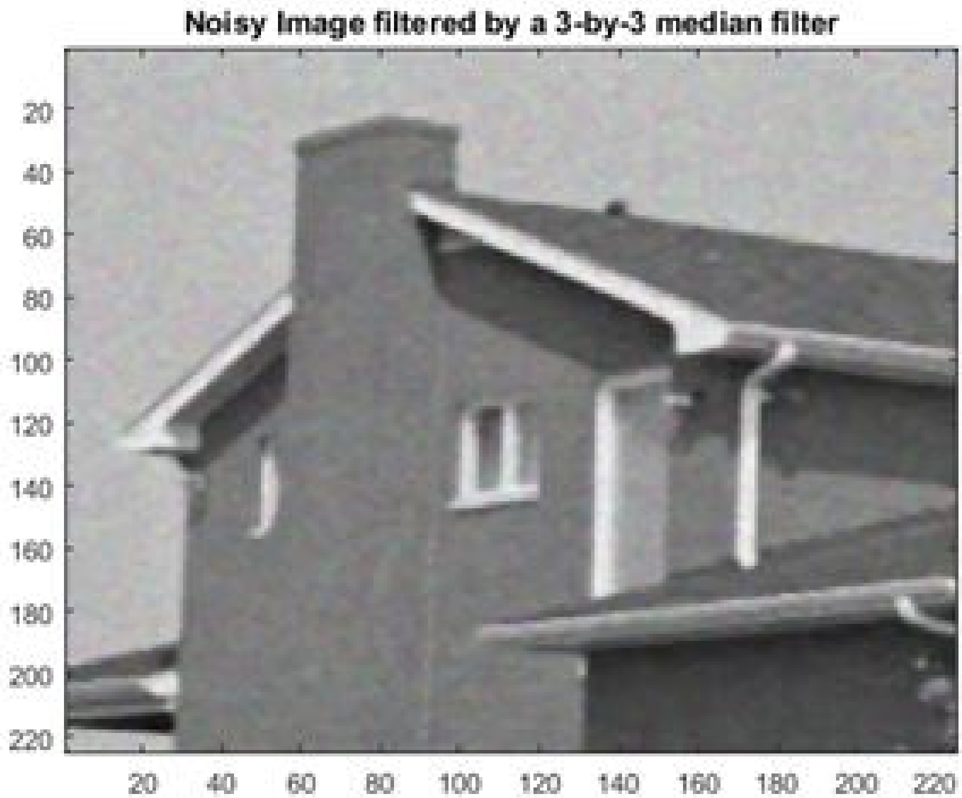

Figure 13: Y = median of MR, MD, C

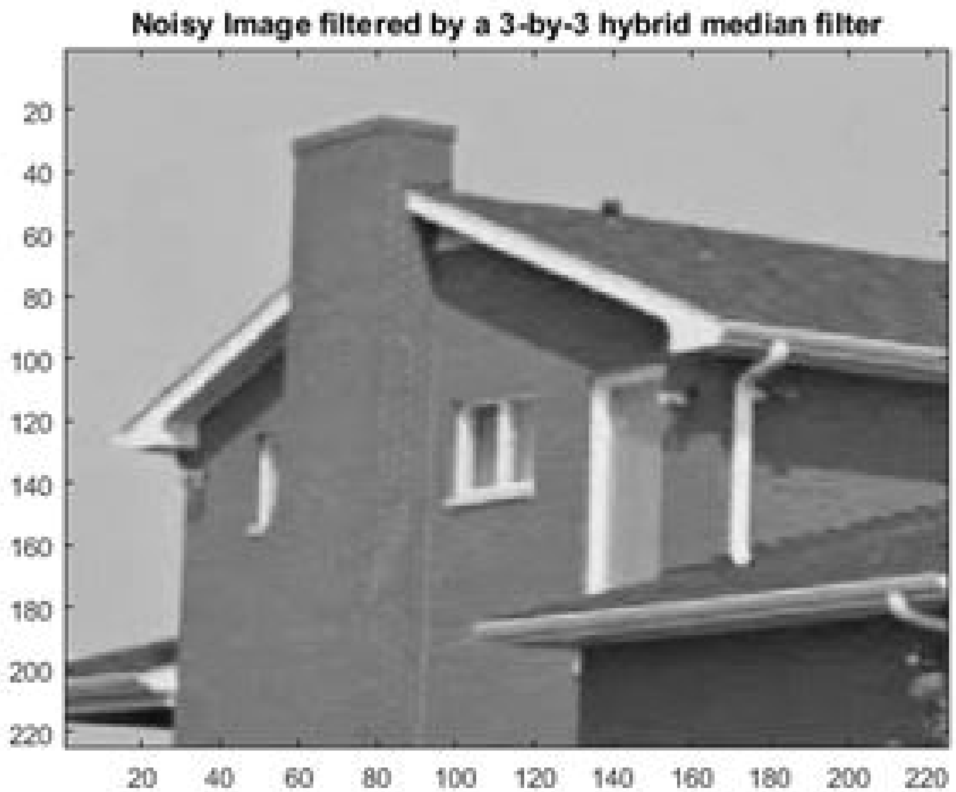

Figure 14: Y = median of MR, MD, C

Image	error	Salt and Pepper				Gaussian				
		Noise	Mean	Median	HMF	Noise	Mean	Median	HMF	Nois
House	MSE	936.28	201.2	32.52	4.02	642.28	157.33	150.3	4.02	138.
	PSNR	18.41	25.09	33.00	42.07	20.05	26.16	26.35	42.07	26.7
	SSIM	0.2538	0.5309	0.9283	0.9843	0.2665	0.5734	0.5168	0.9843	0.529
Lena	MSE	1026.097	333.77	34.1976	2.304	588.5	286.51	147.9	2.304	96.6
	PSNR	18.0189	22.89	32.7908	44.5	20.43	23.55	26.43	44.5	28.2
	SSIM	0.3135	0.6064	0.9728	0.9948	0.3309	0.6725	0.6268	0.9948	0.690
Prawn	MSE	946.291	337.64	269.797	7.421	637.224	295.344	387.938	7.421	11
	PSNR	18.37	22.846	23.8204	39.4262	20.087	23.427	22.243	39.426	27.41
	SSIM	0.3577	0.6233	0.8885	0.9745	0.3819	0.669	0.6065	0.9745	0.709
Rice	MSE	931.981	212.573	48.92	10.66	648.9	166.255	180.828	10.66	110.5
	PSNR	18.436	24.855	31.235	37.849	20	25.923	25.558	37.849	27.69
	SSIM	0.4284	0.6697	0.9063	0.9713	0.4638	0.7122	0.6771	0.9713	0.783
Barbara	MSE	920.523	207.141	53.894	11.36	635.801	164.438	180.114	11.36	117.5
	PSNR	18.49	24.968	30.8154	37.573	20.097	25.9708	25.575	37.573	27.42
	SSIM	0.3966	0.6608	0.9142	0.9779	0.4187	0.7037	0.6529	0.9779	0.735

Figure 15: Y = median of MR, MD, C