Classification of Noisy Image Based on Statistical Feature Extraction & Designing an Adaptive Noise Removal Filter

Kunal Killekar[1] Shruti Belunki[2]
[1]Assistant Professor [2]P.G. Student
[1,2]Department of Electronics and Communication Engineering
[1,2]Maratha Mandal's Engineering College, Belgaum, Karnataka, India

Abstract— The most important challenge in digital image processing is to de-noise the corrupted image. This project reviews existing de-noising algorithms such as AMF, GMF & HMF and their comparative study. In the proposed method first type of noise is detected by extracting the statistical features of corrupted image. In training part we are creating a knowledge base for storing the statistical features of different types of noisy images. In testing part the given query image is classified according to the statistical features by comparing the query image features to the images stored in ANN training. And then the adaptive filter is selected according to type of noise. The output of filter is again requiring tuning so for that we are using Minimum Mean Square Error filter. The result shows the comparison of existing filters with proposed filter by MSE and PSNR values so that proposed filter is efficient and effective.

Key words: AMF-Arithmetic Mean Filter, HMF- Harmonic Mean Filter, GMF- Geometric Mean Filter, PF-Proposed Filter, ANN -Artificial neural network

I. Introduction

Digital images are easily corrupted by noise because of analog-to-digital conversion and transmission over the communication channel and also due to malfunctioning of pixel elements in the camera sensors. Presence of noise degrades the image quality and increases the difficulty in image processing. It is significant to remove noise from the corrupted images before any image processing. However removal of noise from a corrupted image is a difficult task, because images may be corrupted by different types and percentage of noise. The noise added to images can be classified as Gaussian noise, Spackle noise, Salt & pepper noise (Impulse noise) [1].

Selection of the de-noising algorithm is dependent on applications. Hence, it is required that we should have the knowledge about the noise present in the image so that accordingly to select the appropriate de-noising filter. We can suffer the difficulty in filtering and inaccuracy in results by using the single filter for different types of noises. So that it is most important to detect type of noise and percentage of noise accordingly the adaptive filter can be selected.

In this paper proposes a system in which the corrupted query image is first classified according to the type of noise it contains. Corrupted image is classified on the basis of statistical parameters such as mean, standard deviation, entropy, kurtosis and histogram. For classification we are using ANN (Artificial neural network) which is trained and data base is created for the different types and different percentage of noise. According to type and percentage of noise the filter is selected.

The performance of the proposed algorithm is analyzed quantitatively in terms of performance parameters such as Mean Square Error [MSE] and Peak-Signal to Noise Ratio [PSNR], and is compared with other existing algorithms as AMF, GMF & HMF. Extensive simulations show that proposed algorithm is efficiently removes the noise and preserves the edges without any blurring, thus this algorithm produces better results in terms of the qualitative and quantitative measures of the image and plotting graphs.

Types of Noise:

There are various types of noise and they have different characteristics.

A. *Gaussian Noise (Amplifier Noise)*

The Gaussian noise is also called as amplifier noise, Gaussian, is independent at each pixel. The sources of Gaussian noise in digital images adds during acquisition e.g. sensor noise caused due to poor illumination or high temperature, or transmission of an image over communication channel e.g. electronic circuit noise. The standard model of the Gaussian noise is additive and is independent at each pixel and also independent of signal intensity [3].

B. *Impulse Noise (Salt & Pepper Noise)*

Impulse noise is also called as salt-and- pepper noise and also known as spike noise. This type of noise is usually visible on images. The corrupted image consists of white and black pixels. An image corrupted by salt and pepper noise contains two regions bright and dark regions. Bright region contains the dark pixels whereas dark region contains the bright pixels [3].

C. *Speckle Noise*

Speckle is called as 'granular noise'. This type of noise inherently exists in and degrades quality of the active radar and also synthetic aperture radar (SAR) images. Speckle noise in conventional radar is added from random fluctuations in the return signal which is from an object. Speckle noise in SAR is more serious, which causes difficulties in image interpretation. It is mainly caused by coherence of backscattered signals from multiple targets [3].

D. *Types of Existing Filters*

The choice for de-noising a corrupted image is classic linear filters such as Gaussian filter, AMF, GMF, HMF. However these filters have a tendency to blur edges and degrade the images which causes information loss in some important areas [4].

1) Arithmetic Mean Filter

Arithmetic Mean Filtering (AMF) Technique is the simple type of the mean filtering techniques. Let The AMF technique calculate the mean average value of the sub-window of corrupted image g(s,t). AMF smoothed local variations but at the cost of blurring. We can define AMF by the equation,

$f(x,y)=1/mn\sum_{(s,t)} g(s,t)$……………(1)

2) Geometric Mean Filter

Geometric Mean Filtering (GMF) Technique is filtering technique that the restored pixel is given by the product of the all pixels in the sub window, raised to the power of 1/mn. Where m is number of rows and n is number of columns. And g(s,t) is rectangular sub window of size (s,t) of original image. A GMF can achieve smoothness in the image comparable to the AMF but it tends to lose less in image quality. GMF can be expressed by the expression given below. The geometric mean is defined by:

$f(x,y)=[\pi_{(s,t)} g(s,t)]^{1/mn}$…………(2)

GMF performs smoothing as good as AMF but loses image details.

3) Harmonic Mean Filter

In the Harmonic Mean Filtering method, the pixel value of each pixel is replaced with the harmonic mean of values of the pixels in the surrounding region of the sub-window of size (s,t). The harmonic mean filter can work better for removing Gaussian noise and preserving edge features as compared to the arithmetic mean filter. The harmonic mean filtering expression is given by,

$f(x,y)=mn/\sum_{(s,t)} 1/g(s,t)$……………..(3)

HMF works well for Gaussian and salt noise but performs very poor for Pepper noise.

The need of this algorithm is that the Simple filters like AMF, GMF, HMF doesn't involve the mechanism of checking the noisy images so it will filter noisy as well as non noisy Images and information loss may take place, resulted image will be blurred. So it is needed that to know type of noise and percentage of noise first and accordingly the de-noising filter can be selected.

II. IMPLEMENTATION

A. Block Diagram

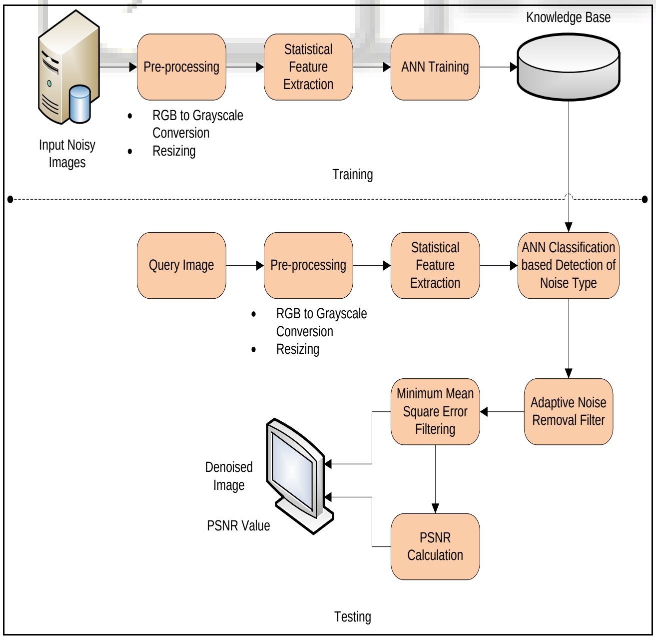


Fig. 1: Block diagram of proposed system

This method is mainly divided into two parts training and testing. In training part we are creating a knowledge base where the training images are stored. Training images are nothing but the preprocessed images i.e. converted into gray features are extracted from a particular image & given to ANN classification according to the features of the image [6]. The statistical features are mean, standard deviation, entropy, kurtosis & histogram.

In testing part the input image or query image is preprocessed & then statistical features of query image are extracted. The extracted features are compared with features of the training images which are stored in the knowledge base & given query image is classified according to the features. So that we can detect which type of noise dose the query image contain. The classified image will be given to the Adaptive Noise removal filter. As per the type of noise type of adaptive filter will be selected for de-noising the corrupted image. If the type of noise is Gaussian then Wiener filter is chosen. IF the noise type is Speckle noise then mean filter is chosen [4]. And if noise type is Salt and pepper noise then EAMF algorithm is chosen [5]. Then the de-noised image is given to the Minimum mean square error filter.

B. Algorithm

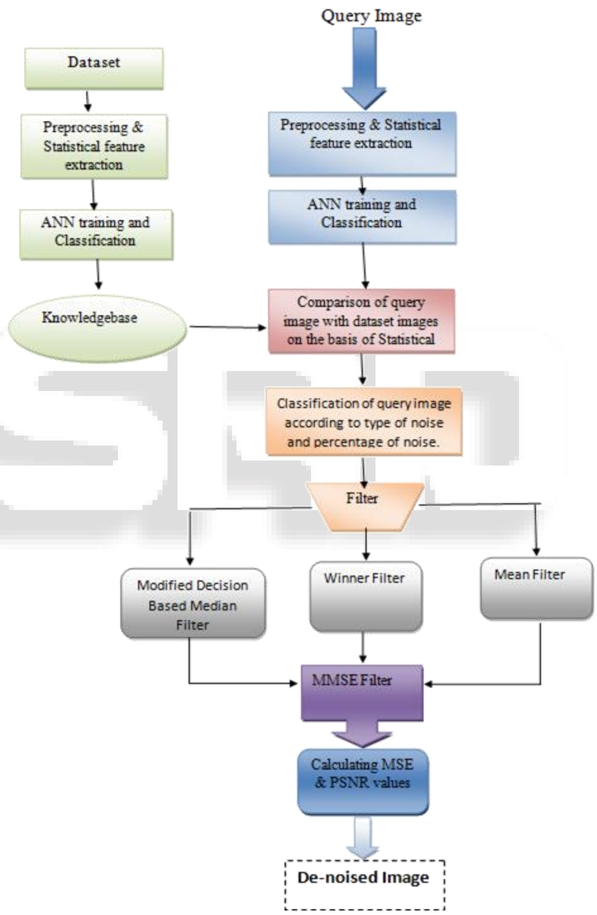


Fig. 2: Flowchart

C. Minimum Mean Square Error Filtering (MMSE)

At most the proposed Adaptive filter can give the visual appearance and fine details in the reconstructed image. However, filter output image's MSE (in between uncorrupted image A and restored image Ā) results will have larger values. To overcome this problem we again pass the image through minimum mean square error filter in proposed filter [2]. The minimum MSE filter's objective is to find an estimate Ā of the uncorrupted image A so that the mean square error between the filtered images is minimized. This error measure is given by:

$E^2 = E\{(A-\bar{A})^2\}$…………………..(4)

Where, E{.} is expected value of the argument.

This minimum MSE filter is used in proposed work to minimize MSE. Then we are checking the performance parameters such as PSNR & MSE.

III. Calculating Performance Measures

A. Mean Squared Error (Mse) and Mean Absolute Error

The mean squared error or MSE is one of the parameter to quantify the amount by which the estimator differs from its true value of the quantity which is being estimated. It is used to calculate the difference value between restored image and original image. The error is amount, by which value of the original image differs from the degraded image [5]. The MSE is defined by,

$$MSE = 1/(M*N)\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(B(i,j)-A(i,j))^2 \ldots\ldots(5)$$

Where,
M-number of columns of an Image,
N-number of columns of an Image,
A-Noisy Image,
B-Original Image.

B. Peak Signal to Noise Ratio (PSNR)

PSNR is a standard mathematical value to measure an objective difference between two images [5]. Reconstructed images should have higher PSNR. Given that original image B of size (m x n) pixels and as reconstructed image A, the PSNR (dB) is defined by,

$$PSNR\ (dB) = 10\log_{10}(255^2/MSE) \ldots\ldots\ldots\ldots(6)$$

IV. Simulation & Results

A. Comparative Result in Table

The following tables shows that the comparison of MSE, PSNR and Processing time required for AMF, GMF, HMF and Proposed filter with respect to different percentage of noise.

1) Comparative Table for Salt & Pepper Noise (Lena.Jpeg)

Filter Type	Noise Value in %	MSE	PSNR	Processing Time in sec
AMF	10	30.6167	0.7010	0.8467
	20	117.8143	37.7748	0.7840
	30	277.6108	35.9136	0.7562
	40	521.1765	34.5458	0.7642
	50	849.4120	33.4800	0.8001
GMF	10	623.1580	34.1578	2.6800
	20	2042.7946	31.5790	4.7032
	30	3888.8181	30.1817	6.7439
	40	5948.9744	29.2585	8.7890
	50	8014.6795	28.6113	11.6639
HMF	10	621.1788	34.1634	0.8769
	20	2034.1830	31.5888	0.9540
	30	3870.9536	30.1917	0.9826
	40	5921.3436	29.2687	1.0719
	50	7980.4186	28.6206	1.2376
Proposed Filter(PF)	10	7.6249	43.7196	1.1576
	20	20.1478	41.6096	1.5277
	30	43.4947	39.9386	1.9020
	40	85.2784	38.4766	2.1128
	50	202.4627	36.5990	2.3401

Table 1: Comparison of results of different filters in terms of MSE, PSNR and Processing time for Salt and Pepper noise

2) Comparative Table for Speckle Noise (Lena.Jpeg)

Filter Type	Noise Value in %	MSE	PSNR	Processing Time in sec
AMF	10	1532.38186	30.689446	0.285758
	20	2930.03816	29.796437	0.287669
	30	5294.62014	27.431115	0.287155
	40	8157.77481	27.468999	0.292567
	50	10214.3812	25.787207	0.292554
GMF	10	1327.77260	32.685214	0.306050
	20	2740.35673	30.788803	0.956185
	30	6117.44323	29.422114	2.193555
	40	8697.89266	28.458844	4.100622
	50	12378.4137	27.775370	6.413519
HMF	10	1227.03259	34.686523	0.012816
	20	2936.61487	33.791569	30.79156
	30	5506.82407	32.426298	0.017979
	40	8578.09601	28.463849	0.021066
	50	11753.9150	27.079891	0.025632
Proposed Filter(PF)	10	88.9576	45.8957	1.1237
	20	90.8768	43.7583	1.3245
	30	144.8571	38.9298	1.9990
	40	165.7845	36.6732	2.8328
	50	234.4879	34.9840	3.1731

Table 2: Comparison of results of different filters in terms of MSE, PSNR and Processing time for Speckle noise

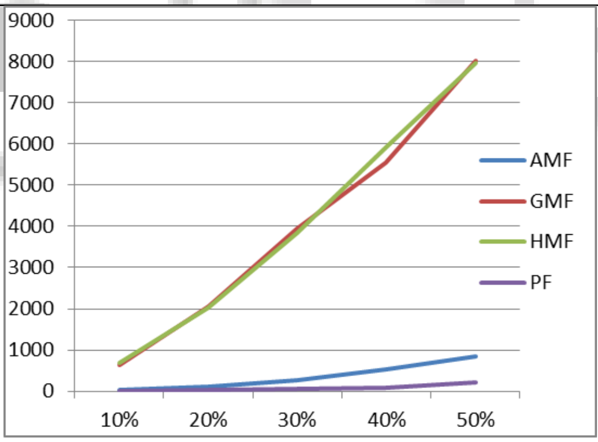
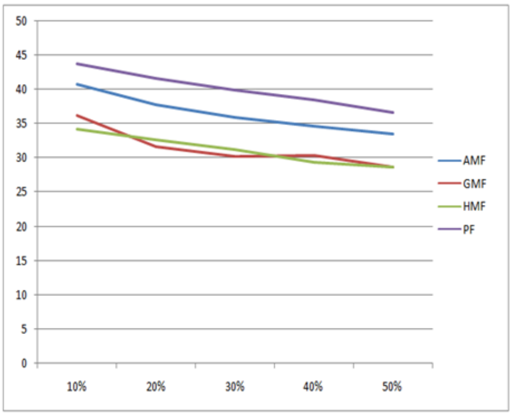
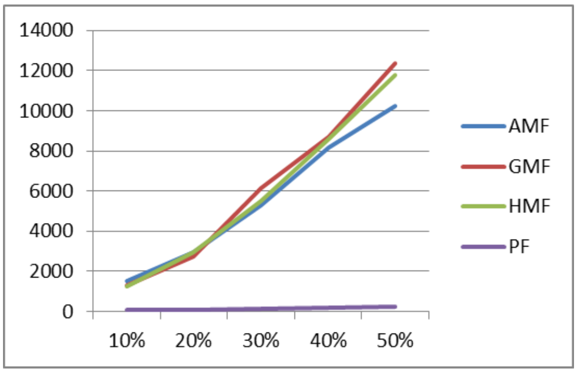
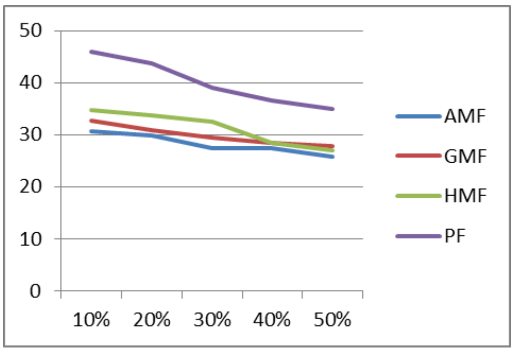
3) Comparative Table for Gaussian Noise (Lena.Jpeg)

Filter Type	Noise Value in %	MSE	PSNR	Processing Time in sec
↓ AMF	10	1537.5845	32.196609	0.281865
	20	2794.0177	30.899658	0.296678
	30	3907.9158	30.171078	0.284816
	40	4126.2706	29.053015	0.287881
	50	4904.0509	27.718306	0.292497
GMF	10	1552.3375	32.175873	0.495803
	20	2857.1989	29.851101	0.936473
	30	4097.4068	30.068258	1.281533
	40	5580.0772	27.397603	2.098667
	50	7020.6472	25.898918	2.952950
HMF	10	1565.7693	37.157165	0.013291
	20	2951.1339	35.780859	0.015600
	30	4473.6931	31.877473	0.015550
	40	6118.6406	31.197529	0.033747
	50	7464.4843	27.76580	0.061027
Proposed Filter(PF)	10	64.3469	60.7196	2.0323
	20	69.7738	53.8993	2.5987
	30	77.8737	42.7845	2.9760
	40	140.7884	38.8729	3.1873
	50	260.8237	32.0937	4.3601

Table 3: Comparison of results of different filters in terms of MSE, PSNR and Processing time for Gaussian noise

B. *Graphical Results*

The graphical results show the comparison of different types of filters and proposed filter (PF)

Noise	MSE vs Percentage of noise	PSNR vs Percentage of Noise
Salt & Pepper		
Speckle		

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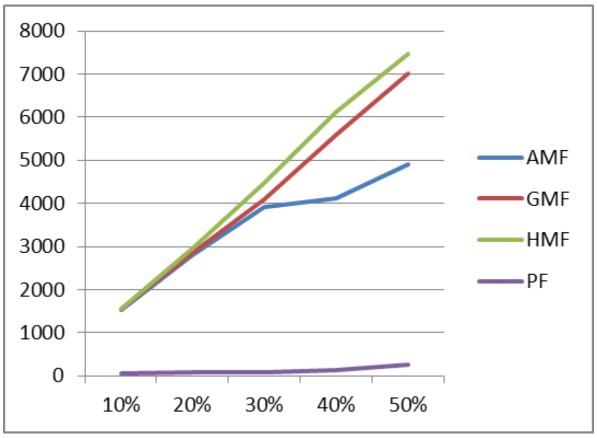
<td>Gaussian</td>
<td>
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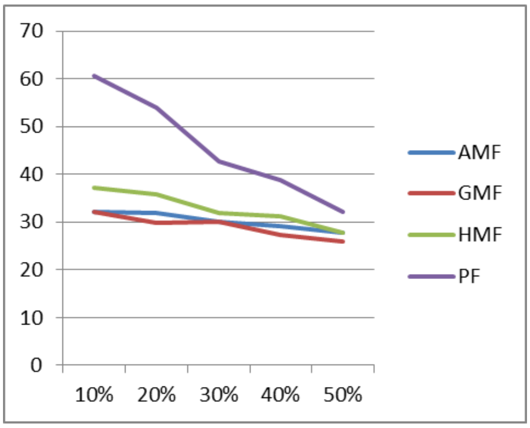
<td>
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Table 4: Graphical comparison

C. *Image Results*

1) *Results for Salt and Pepper Noise*

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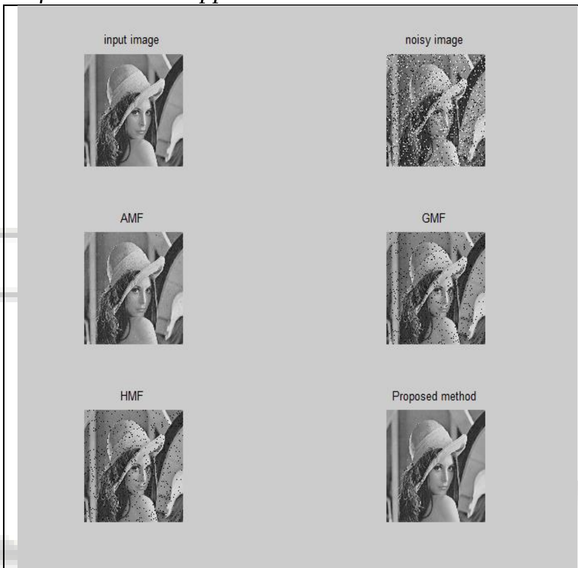
<td>
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<td>Fig-a</td>
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<td>Fig-c</td>
<td>Fig-d</td>
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<tr>
<td colspan="2">Fig. 3: Results of AMF, HMF, GMF and Proposed filter for Salt and Pepper noise,(a) image corrupted by 10% noise, (b) image corrupted by 20% noise, (c) image corrupted by 30% noise(d) image corrupted by 40% noise.</td>
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2) Results for Speckle Noise

Fig-a

Fig-b

Fig-c

Fig-d

Fig. 4: Results of AMF, HMF, GMF and Proposed filter for Speckle noise,(a) image corrupted by 10% noise, (b) image corrupted by 20% noise, (c) image corrupted by 30% noise(d) image corrupted by 40% noise.

3) Results for Gaussian Noise

Fig-a

Fig-b

Fig-c

Fig-d

Fig. 5: Results of AMF, HMF, GMF and Proposed filter for Gaussian noise,(a) image corrupted by 10% noise, (b) image corrupted by 20% noise, (c) image corrupted by 30% noise(d) image corrupted by 40% noise.

V. CONCLUSION

In this paper, we have proposed a system which has simple and effective algorithm to remove the Gaussian, Salt & Pepper noise and Spackle noise from given noisy image. At first, the type of noise is detected and then according to detected noise type and percentage the adaptive filter is selected for de-noising the image. The MSE and PSNR values show the comparative results of different types of noise and amount of noise for different types of filters. Using these values we plot the graph of different filters with respect to percentage of noise. But this algorithm some more processing time as compared to other algorithms.

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