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IMAGE DE-NOISING BY MODIFIED NON-LINEAR FILTER FOR DIFFERENT NOISES

M.S.Vaishnavi[1], R. Sai Saketh Pawan[2], Dr. M. Narsing Yadav[3]

1. Senior UG student, MRIET, Hyderabad. Email: vaishnavi.ms123@gmail.com
2. Senior UG student, MRIET, Hyderabad. Email: r.saketh20@gmail.com
3. Professor, HOD ,Dept of ECE, MRIET. Email: narsing.mriet@gmail.com

ABSTRACT

Images are often degraded by noises. Noise can occur during image capture, transmission, etc. Noise removal is an important task in image processing. In general the results of the noise removal have a strong influence on the quality of the image processing technique. Several techniques for noise removal are well established in color image processing. There are different types of noises which corrupt the images. These noises are appeared on images in different ways: at the time of acquisition due to noisy sensors, due to faulty scanner or due to faulty digital camera, due to transmission channel errors, due to corrupted storage media. In the field of image noise reduction several linear and non linear filtering methods have been proposed. Linear filters are not able to effectively eliminate impulse noise as they have a tendency to blur the edges of an image. On the other hand non linear filters are suited for dealing with impulse noise. In this paper, we present a survey on removal of different types of Noises using non-linear (median filter) for different images. We have considered eight types of noises: Impulse noises, Speckle noise, Gaussian noise, Shot noise, Periodic noise. We analyze all noise removal algorithm for each noise from each of these images. At the end of our study, we present comparative study of all these noises using median filter.

Keywords: *Non-linear filter, Median filter, Gaussian noise, Salt and pepper noise, Shot noise, Speckle noise MSE and PSNR value.*

1. INTRODUCTION

Noise is the result of errors in the image acquisition process that results in pixel values that do not reflect the true intensities of the real scene. Noise reduction is the process of removing noise from a signal. Noise reduction techniques are conceptually very similar regardless of the signal being processed, however a priori knowledge of the characteristics of an expected signal can mean the implementations of these techniques vary greatly depending on the type of signal. The image captured by the sensor undergoes filtering by different smoothing filters and the Resultant images. All recording devices, both analogue and digital, have traits which make them susceptible to noise. The fundamental problem of image processing is to reduce noise from a digital color image.

The two most commonly occurring types of noise are i) Impulse noise, ii) Additive noise (e.g. Gaussian noise) [2] and iii) Multiplicative noise (e.g. Speckle noise). Impulse noise is usually characterized by some portion of image pixels that are corrupted, leaving the remaining pixels unchanged [1]. Examples of impulse noise are fixed-valued impulse noise and randomly valued impulse noise. We talk about additive noise when value from a certain distribution is added to each image pixel, for example, a Gaussian distribution. Multiplicative noise is generally more difficult to remove from images than additive noise because the intensity of the noise varies from the signal intensity (e.g., speckle noise).

2. SOURCES OF NOISE IN DIGITAL IMAGES

Noise usually quantified by the percentage of pixels which are corrupted. Corrupted pixels are either set to the maximum value or have single bits. There are several ways that noise can be introduced into an image, depending on how the image has been created. For instance:

• If the image is scanned from a photograph made on film, the film grain is a source of noise. Noise may also be the result of damage to the film, or be introduced by the scanner itself.

• If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise.

• Electronic transmission of image data can make noise.

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3. TYPES OF NOISES

Noise to be any degradation in the image signal caused by external disturbance. If an image is being sent electronically from one place to another via satellite or wireless transmission or through networked cables, we may expect errors to occur in the image signal. These errors will appear on the image output in different ways depending on the type of disturbance in the signal. Usually we know what type of errors to expect and the type of noise on the image, hence we investigate some of the standard noise for eliminating or reducing noise in color image.

3.1 Amplifier Noise (Gaussian noise)

Gaussian noise is statistical in nature. Its probability density function equal to that of normal distribution, which is otherwise called as Gaussian distribution. In this type of noise, values of that the noise are being Gaussian-distributed. A special case of Gaussian noise is white Gaussian noise, in which the values always are statistically independent. For application purpose, Gaussian noise is also used as additive white noise to produce additive white Gaussian noise. Gaussian noise is commonly defined as the noise with a Gaussian amplitude distribution, which states that nothing the correlation of the noise in time or the spectral density of noise. Gaussian noise is otherwise said as white noise which describes the correlation of noise. Gaussian noise is sometimes equated to be of white Gaussian noise, but it may not necessarily the case.

$$p(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}} , \quad (1)$$

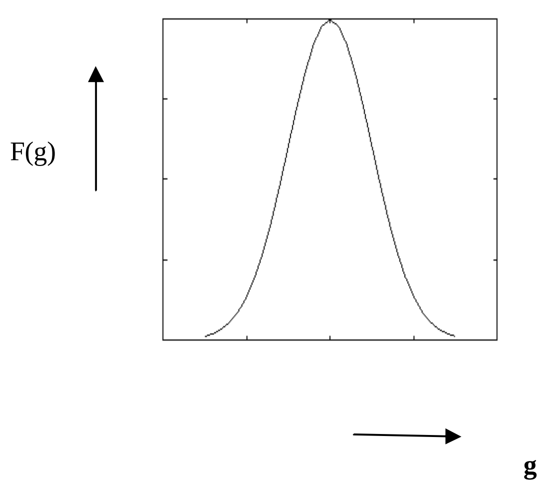

Fig 1: PDF for Gaussian noise

3.2 Salt-and-Pepper Noise (Impulse Noise)

Salt and pepper noise is sometimes called impulse noise or spike noise or random noise or independent noise. In salt and pepper noise (sparse light and dark disturbances), pixels in the image are very different in color or intensity unlike their surrounding pixels. Salt and pepper degradation can be caused by sharp and sudden disturbance in the image signal. Generally this type of noise will only affect a small number of image pixels. When viewed, the image contains dark and white dots, hence the term salt and pepper noise [13]. Typical sources include flecks of dust inside the camera and overheated or faulty (Charge-coupled device) CCD elements. An image containing salt-and-pepper noise will have dark pixels in bright regions and vice versa. This type of noise can be caused by dead pixels, analog-to digital converter errors and bit errors in transmission.

$$HISTOGRAM_{Salt\&Pepper} = \begin{cases} A & for\ g = a\ ("pepper") \\ B & for\ g = b\ ("salt") \end{cases} \quad (2)$$

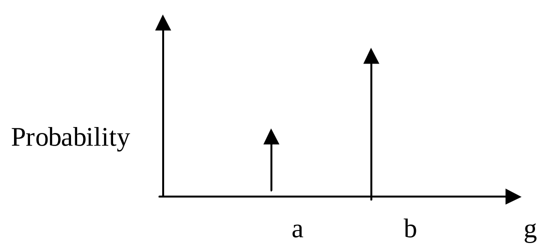

Fig 2: Histogram for salt and pepper noise

3.3 Shot Noise

The dominant noise in the lighter parts of an image from an image sensor is typically that caused by statistical quantum fluctuations, that is, variation in the number of photons sensed at a given exposure level; this noise is known as photon shot noise. Shot noise has a root mean- square value proportional to the square root of the image intensity, and the noises at different pixels are independent of one another. Shot noise follows a Poisson distribution, which is usually not very different from Gaussian. In addition to photon shot noise, there can be additional shot noise from the dark leakage current in the image sensor; this noise is otherwise known as "dark shot noise" or "dark-current shot noise".

3.4Speckle Noise (Multiplicative Noise)

Speckle noise is a granular noise that inherently exists in and degrades the quality of the active radar and synthetic aperture radar (SAR) images. Speckle noise in conventional radar results from random

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fluctuations in the return signal from an object that is no bigger than a single image processing element. It increases the mean grey level of a local area. Speckle noise in SAR is generally more serious, causing difficulties for image interpretation. It is caused by coherent processing of backscattered signals from multiple distributed targets. In SAR oceanography [5], for example, speckle noise is caused by signals from elementary scatters, the gravity-capillary ripples, and manifests as a pedestal image, beneath the image of the sea waves.

$$p_A(a) = \frac{a}{\sigma^2} exp\left(-\frac{a^2}{2\sigma^2}\right), a \geq 0 \quad (3)$$

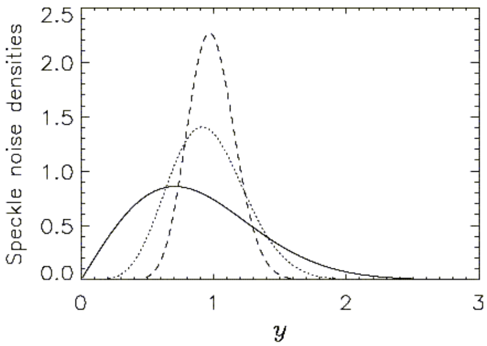

Fig 3: PDF for speckle noise

4. REMOVING NOISE FROM IMAGES BY FILTERING

Image noise is an unavoidable side-effect occurring as a result of image capture, more simply understood as inaudible, yet inevitable fluctuations. In a digital camera, if the light which enters the lens misaligns with the sensors, it will create image noise. Even if noise is not so obviously visible in a picture, some kind of image noise is bound to exist. Every type of electronic device receives and transmits some noise and sends it on to what it is creating. When the images are transmitted over channels, they are corrupted with impulse noise due to noisy channels. This impulse noise consists of large positive and negative spikes. The positive spikes have values much larger than the background and thus they appear as bright spots, while the negative spikes have values smaller than the background and they appear as darker spots. Both the spots for the positive and negative spikes are visible to the human eye. Also, Gaussian type of noise affects the image. Thus, filters are required for removing noises before processing. There are lots of filters in the paper to remove noise. They are of many kinds as linear smoothing filter, median filter, wiener filter and Fuzzy filter. In this filtering technique, the three primaries(R, G and B) are done separately. It is followed by some gain to compensate for attenuation resulting from the filter. The filtered primaries are then combined to form the colored image. This process is very simple. This approach is shown in figure 1.

4.1 Non-Linear Filters

In recent years, a variety of nonlinear median type filters such as weighted median, rank conditioned rank selection, and relaxed median have been developed to overcome this short coming.

4.1.1 Median Filter

A median filter is an example of a non-linear filter and, if properly designed, is very good at preserving image detail. To run a median filter:
1. Consider each pixel in the image
2. Sort the neighboring pixels into order based upon their intensities
3. Replace the original value of the pixel with the median value from the list. The Median filter is a preprocessing technique to the performance of the later technique also called as nonlinear digital filter. Median filter have wide use in image processing to remove the noise from corrupted images, at the same time it preserves smooth edges and also useful details in the image. The basic theme of the median filter is to go through the signal, entry by entry, further swapping it with the median of neighboring entries. The median filter is a dynamic filter which works like smoothers for image processing, as well as time series processing and in signal processing. A major advantage of the median filter is that it can eliminate the effect of input noise values with extremely large magnitudes. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. Let the output generated by median filter be "M" at the moment x is calculated as the median of the input values corresponding to the moments adjacent to x:

M(x) = median ((M(x-T/2), M(x-T1+1),…….., M(x),...,M(x+ T/2)). (4)

Where x is the size of the window of the median filter. The one-dimensional median filter described above.

Normally images are represented in discrete form as two-dimensional arrays of image elements, or "pixels" –
i.e. sets of non-negative values Bij ordered by two indexes –
i =1,..., N y(rows)

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And j =1,...,N y(column).
Where the elements Bij is the scalar values, there are methods to process color images, where each pixel can be represented by values, such as by its "red", "green", "blue" values determining the color of the pixel.

5. PROPOSED ALGORITHM

The proposed Modified Non-linear Filter algorithm processes the corrupted images by first detecting the noisy pixels in the image. To check processing pixel is noisy or noise free by verifying whether it lies between maximum and minimum grey level values then it is noise free pixel, else pixel is said to be corrupted. Only corrupted pixels are processed to replace with noise free pixel value, uncorrupted pixels are left unchanged. The steps of Modified Non-linear filter are elucidated as follows.

ALGORITHM

Step 1: Select 2-D window of size 3 x 3. Assume that the pixel being processed is P_{ij}.
Step 2: If $0 < P_{ij} < 255$ then P_{ij} is an uncorrupted pixel and its value is left unchanged. This is illustrated in case iii) of Section IV.
Step 3: If $P_{ij} = 0$ or $P_{ij} = 255$ then P_{ij} is_ corrupted pixel then two cases are possible as given in case 1) and 2).
Case 1): If the selected window contains not all elements as 0's and 255's. Then eliminate 0's and 255's from window and find the median of the remaining pixels. Replace P_{ij} with the median value.
Case 2): If the selected window contains all the elements as 0's and 255's. Then it again draws few steps:
Step i: Increase the window size by two. Contains three cases
Case i): If increased window contains not all elements as 0's and 255's.Then eliminate 0's and 255's from window and find the mean of remaining pixels. Replace P_{ij} with the mean value.
Case ii): If increased window contains all 0's and 255 and maximum window size limit not reached then follow step i.
Case iii): If increased window contains all 0's and 255 and maximum window limit has reached. Then find out mean of the elements in window and replace that value in P_{ij}.
Step 4: Repeat steps 1 to 3 until all pixels in the entire image are processed.

The pictorial representation of each case of proposed algorithm is shown in Fig. 1.
The detailed description of each case of flowchart shown in Fig. 1 is illustrated through an example in section IV.

4. ILLUSRATION OF MNF ALGORITHM

Each and every pixel of the image is processed for checking salt and pepper noise. Different cases are illustrated in this section.

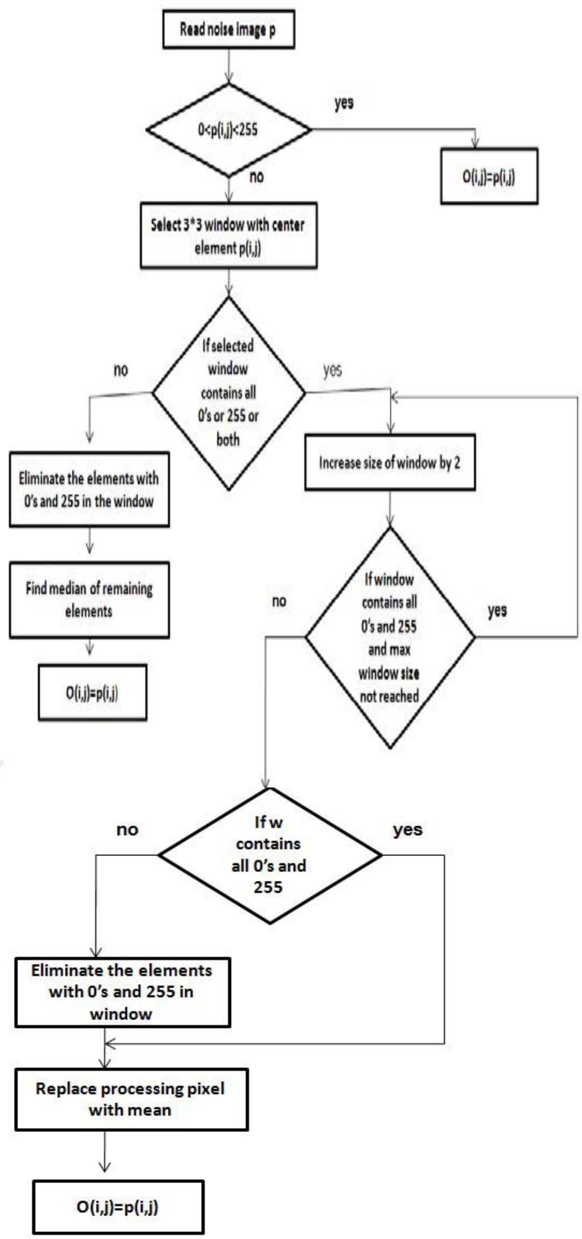

Fig 4 :Flow chart of MNF

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Case i): If the processing pixel is not noisy pixel contains all values in between minimum and maximum grey level values then processing pixel is not changed
Case ii): If the processing pixel is noisy remove all 0's and 255's, calculate the median value of the Remaining pixel values.

$$\begin{pmatrix} 78 & 90 & 0 \\ 97 & 255 & 73 \\ 120 & 0 & 255 \end{pmatrix}$$

Case iii): If the selected window contains processing pixel noisy and also all the window elements are 0's and 255's

$$\begin{pmatrix} 0 & 255 & 0 \\ 0 & 255 & 255 \\ 255 & 0 & 255 \end{pmatrix}$$

Then two steps are drawn:
Step i): Increase the window size if maximum window limit has not reached .This again draws cases.
Case 1): After increasing the window not having all 0's and 255's.

$$\begin{pmatrix} 0 & 255 & 0 & 80 \\ 0 & 255 & 255 & 255 \\ 255 & 120 & 0 & 60 \\ 255 & 30 & 150 & 40 \end{pmatrix}$$

Then remove pixels with 0's and 255's and that result [80 150 120 60 40 30].Find the mean of this pixels is 80.This is replaced with processing pixel.
Case 2):After increasing if window contains all o's and 255's then follow step ii.
Step ii):If maximum window size is reached and even the window has all 0's and 255's then find of all elements .Replace the value with processing pixel,

5. SIMULATION RESULTS

The performance of proposed algorithm is tested for different noises. De-noising performances are quantitatively measured by the PSNR and IEF as defined in (4) and (7)

$$PSNR\ in\, dB = 10\log_{10}\left(\frac{255^2}{MSE}\right) \quad (1)$$

$$MSE = \frac{\sum_i \sum_j (Y(i,j) - \hat{Y}(i,j))^2}{M \times N} \quad (2)$$

$$IEF = \frac{\sum_i \sum_j (\eta(i,j) - Y(i,j))^2}{\sum_i \sum_j (\hat{Y}(i,j) - Y(i,j))^2} \quad (3)$$

Table I: Comparison Of PSNR Values and MSE values of Different Noises
.

Different Noise	PSNR value	MSE value
Salt and pepper noise (10%)	33.3212	30.2666
Gaussian noise	23.3015	304.3095
Poisson noise	31.6686	44.2809
Speckle noise	24.7863	215.7863

From the results we obtained, it shows that the salt and pepper noise affected image is effectively de-noised with median filter so we get low MSE and high PSNR value compared to other filtered noise and median filter shows average removal of noise for Poisson noised image. But, when compared to salt and pepper and Poisson noise, Gaussian and speckle noise produces high. So it is observed that Median filter is not an appropriate filter for Gaussian noise and speckle noise.

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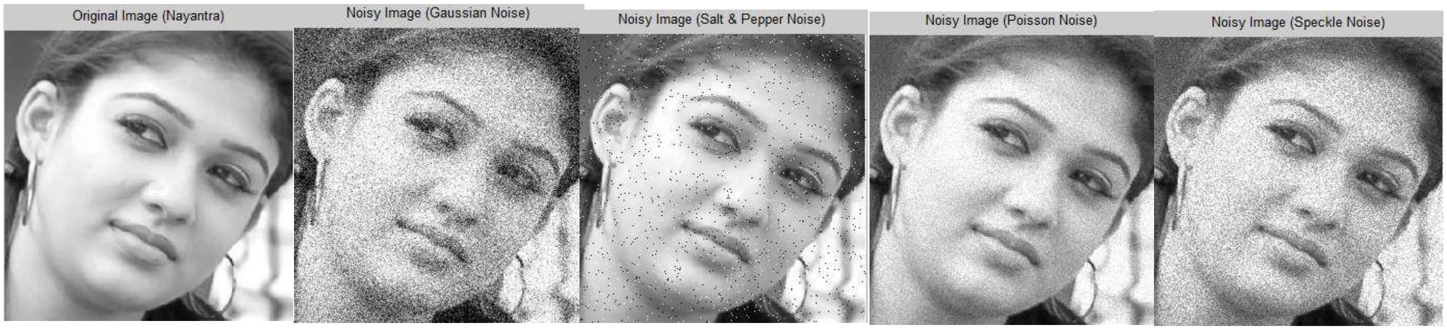

(a) (b) (c) (d) (e)

Fig 5(a) Original image,(b)Gaussian noise,(c)Salt and pepper noise,(d) Poisson noise,(e)Speckle noise

(a) (b) (c) (d) (e)

Fig 6(a)median filter original image,(b)de-noising by median filter(Gaussian noise),(c)de-noising by median filter(salt and pepper noise),(d)de-noising by median filter(Poisson noise),(e)de-noising by median filter(speckle noise)

6 . CONCLUSION:

In this paper, we used an image ,adding four noise (Speckle, Gaussian ,Poisson and Salt & Pepper) in original image with standard deviation(0.025) (figure 5) ,De-noised all noisy images by median filter and conclude from the results (figure 6) .The performance of the Median Filter after de-noising for salt and pepper noise is better than Speckle, Poisson and Gaussian noise. Median filter reveals better results PSNR and MSE values compared to other noises.

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