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Survey of Noise in Image and Efficient Technique for Noise Reduction

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Abstract: ***Removing noise from the image is big challenge for researcher because removal of noise in image causes the artifacts and image blurring. Noise occurred in image during the time of capturing and transmission of the image. There are many methods for noise removal from the images. Many algorithms and techniques are available for removing noise from image, but each method exist their own assumptions, merits and demerits. Noise reduction algorithms for remove noise is totally depends on what type of noise occur in the image. In this paper, focus on some important type of noise and noise removal techniques is done.***

Keywords: Impulse noise, Gaussian noise , Speckle noise ,Poisson noise, mean filter, median filter ,etc

1. Introduction

Digital image processing is using of algorithms for improve quality order of digital image .This error on image is called noise in image which do not reflect real intensities of actual scene. There are two problems found in image processing: Blurring and image noise. Noise image occurred by many reasons:

- When we capture image from camera (scratches are available in camera).
- Image transmission through different media.
- Digitization process.
- Environmental factor (everywhere faced with pollution so real scene are not captured).

Noise can introduce by transmission errors and compression. So noise reduction is most important task for improve quality of image .Denoising technique is often a necessary and the take first step, before analysed the image data. It is important apply denoising technique to compensate for such data corruption. Denoising techniques still remains big challenge for researchers because noise removal introduced artifacts and causes blurring of an images. Image denoising techniques depend on what type of noise occurred in image like Gaussian noise, shot noise, etc.

2. Different Types of Noise

Noise is introduced by imaging system and noise occurred in image during image acquisition or transmission or capturing etc .Depending on the type of noise ,noise can affect image to different extend . Normally, we focus on to remove different type of noise .So identifies the noise in image and relatively noise removal algorithm applies. Image noise can be classified as: Amplifier noise (Gaussian noise), shot noise (Photon noise), Uniform noise, On-isotropic noise, Multiplicative noise (speckle noise), periodic noise, uniform noise, etc.

a) **Impulse noise (Salt and Pepper noise):** In Impulse noise, dark and bright spot appear in the image as a result of noise and hence salt and pepper noise. Dust particles present on the camera during capturing image or over heated faulty component can cause noise arise in image because of sharp and sudden changes of image signal.

$$I_{sp}(i,j) = \begin{cases} I(i,j) & x < l \\ I_{min} + Y(I_{max} - I_{min}) & x > l \end{cases}$$

x,y∈[0,1] are two uniformly distributed random variables

Figure 1: Original image

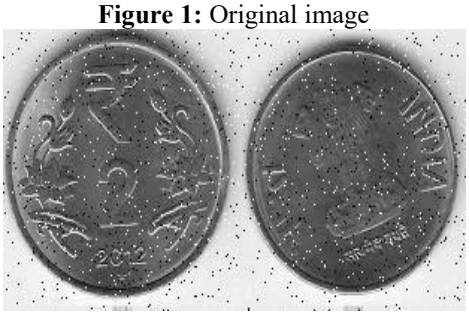


Figure 2: Image with 30% noise

b) **Gaussian noise (Amplifier noise):** Other term used for Gaussian noise is like white Gaussian noise, zero-mean stochastic process. Gaussian noise follows Gaussian distribution. Each pixel is sum of true pixel value and Gaussian distribution noise value.
White –n(i ,j) independent in both space and time
Zero mean I(i,j)=0
Gaussian –n(i,j) is random variable with distribution

$$p_{(x)} = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{x^2}{2\sigma^2}}$$

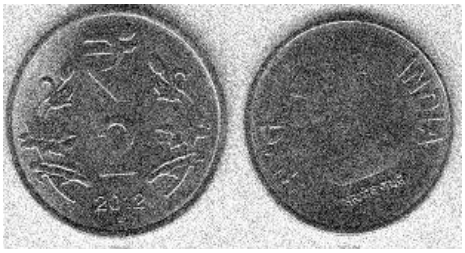


Fig3: Gaussian noise with zero mean

c) **Shot noise:** Shot noise is uses some other terms like photon noise , Poisson noise .This noise in the darker parts of an image from an image sensors cause by statistical quantum fluctuations i.e. variation in the number of photons sensed at a given exposure level. This noise has root mean square value proportional to square root intensity in the image.

$$SNR=\frac{N}{\sqrt{N}}=\sqrt{N}$$

Figure 4: Image with Shot noise

d) **Speckle noise:** Speckle noise is also known as multiplicative noise. Speckle noise by random value multiplications with pixel values of the image.

$$J=I+ n*I$$

Where J is speckle noise distribution image
I is input image
N is uniform noise image by mean o and variance v where v default value is 0.04.

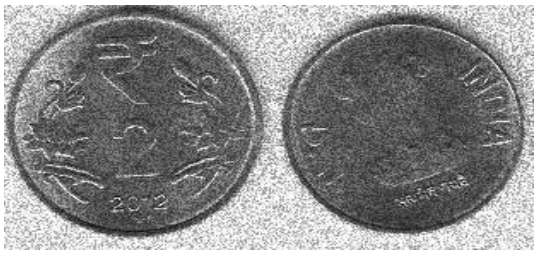


Figure 5: Image with speckle noise

e) **Uniform noise:** Uniform noise is dependent on signal approximately uniform distribution .It will be signal dependent if filtering is explicitly applied. Noise caused by quantizing the pixels of a sensed image to a number of discrete levels is known as **quantization noise**.

f) **Film grain:** Film grain is signal dependent noise if film grain are uniformly distributed and independent probability of developing to a dark silver grain after absorbing photons then number of such dark grains in an area will be random with a binomial distribution.

Figure 6: Image with film grain noise

3. Noise Filtering Techniques

Noise filtering techniques are classified in two parts:

i. **Spatial Domain**: Spatial domain is a traditional method to remove noise from image is utilize spatial filter . Spatial filters are high speed tools of image. Spatial domain technique is further classified:

a) Linear filter: Linear filter are further classified into:

1) Mean filter: Mean filters are simple sliding window spatial filter. In mean filters replaces the centre value in the window with average of all pixel values in window.

Figure 7: Mean filter used on impulse noise

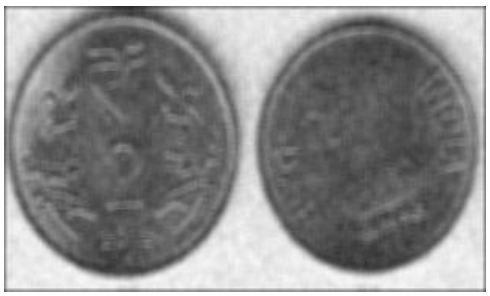


Figure 8: Mean filter with Gaussian noise

Figure 9: Mean filter with Poisson noise

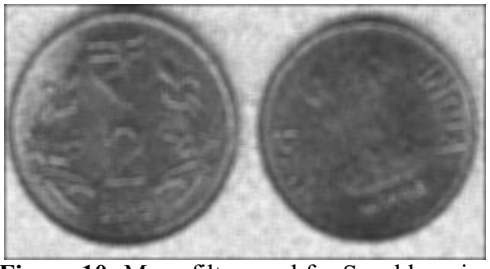
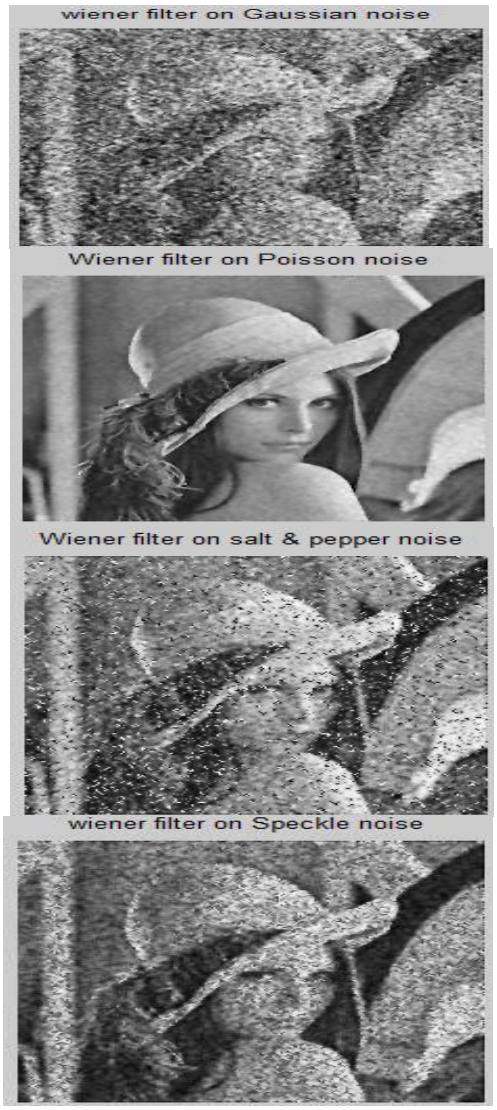


Figure 10: Mean filter used for Speckle noise

2) **Weiner filter:** Weiner filter collect information regarding spectra of noise and original signal. If works only when underlying signal is smooth. This method implements spatial smoothing.



(b) Non-linear filters: In this method, we removed noise without any attempt to explicitly identify it. Spatial filters use a low pass filtering o group of pixels. It assumed noise occupies the higher version of frequency spectrum. Many filters make for overcome this drawback: Weighted median, rank conditioned rank selection, relaxed median.

(i) **Median filter:** This filter is best non-linear filter. Median filters response is based on the ranking pixel values contained in filter region .This method good for salt and pepper noise .It used for smoothing for image processing as well as signal processing .Main advantage of median filter, it can eliminate the effect of input values with extremely large magnitudes.

Figure 11: Median filter used for impulse noise

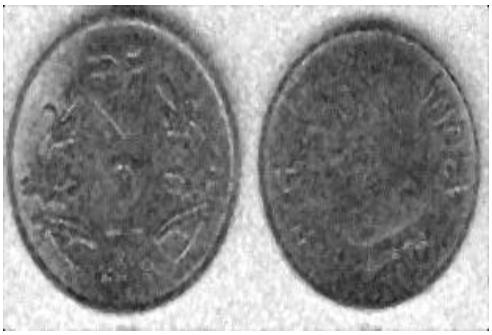


Figure 12: Median filter used for Gaussian noise

Figure 13: Median filter used for Poisson noise

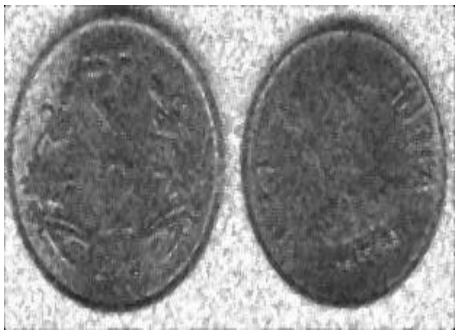


Figure 14: Median filter used for Speckle noise

(ii) Transform Domain: Transform domain method, subdivided according to choices of basic functions. It classified into two parts:

1) **Data adaptive:** This is non-local image modelling technique .This is based on adaptive, high order group-wise models.BM3D is an adaptive filter.

Figure 15: BM3D filter used for impulse noise

Figure 16: BM3D filter used for Gaussian noise

Figure 17: BM3D filter used for Poisson noise

Figure 18: BM3D filter used for Speckle noise

2) **Non-adaptive transform:** This technique is divided into two types:
   a) **Spatial frequency filtering:** It refers use of low pass filtering using fast Fourier transform.In frequency smoothing technique the removal of the noise is achieved by designing a frequency domain filter and adapting a cut-off frequency when the noise mechanism are decorrelated from the useful signal in the frequency domain. These methods are time consuming and depend on the cut-off frequency and the filter function behavior. Furthermore, they may generate artificial frequencies in the processed image.
   b) **Wavelet Domain**: Wavelet domain is classified as: Linear filtering, non-linear threshold filtering, wavelet coefficient model, non-orthogonal wavelet transform .Wiener Filter in the Wavelet domain performs better than thresholding methods and Wiener Filter in the Fourier Domain. Improve denoising along the edges.

4. Conclusion

In this paper we discussed about different types of noises present in the images along with few noise reduction techniques. Different types of noise have different effect on the image. We can identify the type of noise from the image itself and many filters can be applied on the image to remove the noise from the image.

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