Handling of Digital Pictures in Noise Simulations and Its Removal Techniques

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***Abstract*—**
With the continuous development of computer science and technology, image processing and analysis gradually form the scientific system. Digital Pictures Noise is ever present during Picture gaining, coding, transmission, and processing steps. It is most problematic to eliminate it from the Digital Picture without the prior information of noise model. In the review of noise models are vital in the study of picture de-noising methods. In this paper, we express abbreviated summary of several noise simulations. These noise simulations can be certain by examination of their source. In this way, we present a complete and measurable analysis of noise models available in digital pictures.

***Keywords*— Noise Simulations, Digital Pictures, Handling of Pictures, Types of Noises Simulations.**

I. INTRODUCTION

The digital image processing technology is an inter-disciplinary arena. With the endless expansion of computer science and technology, image processing and analysis gradually shaped the systematic structure. Digital image is extensively used in the world, such as education, advertisement, video, film, and so on. The most common processing tasks are noise filtering and enhancement, since these are essential functions of any image processing system, regardless of whether the processed image is utilized for visual interpretation or automatic analysis.

The noise in imaging system usually presents during image acquisition, coding, transmission, and processing steps. Several Applied advances, of considerable interest in the field of image de-noising, need continuous and uniform review of relevant noise theory. Countless researchers have addressed literature survey of given practical as well as theoretical aspects.

This noise appearance disturbs the original information in voice, image and video signal. In this sense some questions arises in researches mind, how much original signal is corrupted, how we can reconstruct the signal, which noise model is associated in the noisy image.

However time to time we have to need the reinforcement learning of theoretical and practical ideas of entire noises present in digital images. Here, we are trying to present the solution of all these problems through the review of noise models. In this paper, the literature survey is based on statistical concepts of noise theory.

These noises may be came from a noise sources present in the vicinity of image capturing devices, faulty memory location or may be introduced due to imperfection/inaccuracy in the image capturing devices like cameras, misaligned lenses, weak focal length, scattering and other adverse conditions may be present in the atmosphere. This makes careful and in-depth study of noise and noise models are essential ingredient in image de-noising. This leads to selection of proper noise model for image de-noising systems [1-3].

II. NOISE MODELS

Noise produces unwanted effects such as artifacts, unrealistic edges, unseen lines, corners, blurred objects and disturbs background scenes. To reduce these undesirable effects, prior learning of noise models is essential for further processing. Digital noise may arise from various kinds of sources.

- Charge Coupled Device (CCD)
- Complementary Metal Oxide Semiconductor (CMOS) sensors.
- Points Spreading Function (PSF)
- Modulation Transfer Function (MTF)
- Probability density function (PDF)
- Histogram is also used to design and characterize the noise models.

Here we will discuss few noise models, their types and categories in digital images [4].

2.1. GAUSSIAN NOISE MODEL

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The term normal noise model is the synonym of Gaussian noise. This noise model is additive in nature and follow Gaussian distribution. Meaning that each pixel in the noisy image is the sum of the true pixel value and a random, Gaussian distributed noise value. The noise is independent of intensity of pixel value at each point. The PDF of Gaussian random variable is given by: P(x) = 1/ (σ√2π) *e (x-μ)2 / 2σ 2 -∞ < 0

Where: P(x) is the Gaussian distribution noise in image; μ and σ is the mean and standard deviation respectively. Figure 1, shows the effect of adding Gaussian noise with zero mean

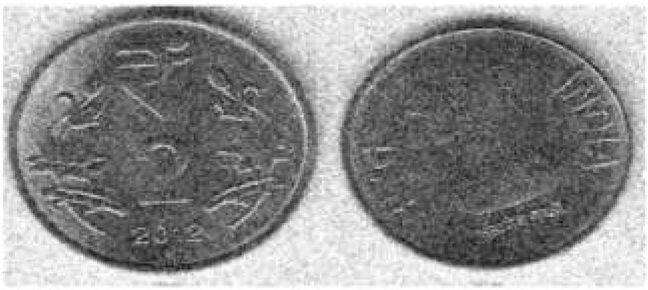

Figure 1 Gaussian noise with zero mean

2.2 WHITE NOISE

Noise is essentially identified by the noise power. Noise power spectrum is constant in white noise. This noise power is equivalent to power spectral density function. The statement "Gaussian noise is often white noise" is incorrect [4].

However neither Gaussian property implies the white sense. The range of total noise power is -∞ to +∞ available in white noise in frequency domain. That means ideally noise power is infinite in white noise. This fact is fully true because the light emits from the sun has all the frequency components.

In white noise, correlation is not possible because of every pixel values are different from their neighbours. That is why autocorrelation is zero. So that image pixel values are normally disturb positively due to white noise.

2.3 BROWNIAN NOISE (FRACTAL NOISE)

Colored noise has many names such as Brownian noise or pink noise or flicker noise or 1/f noise. In Brownian noise, power spectral density is proportional to square of frequency over an octave i.e., its power falls on ¼ th part (6 dB per octave). Brownian noise caused by Brownian motion.

Brownian motion seen due to the random movement of suspended particles in fluid. Brownian noise can also be generated from white noise, which is shown in Fig. 2.

However this noise follows non stationary stochastic process. This process follows normal distribution. Statistically fractional Brownian noise is referred to as fractal noise. Fractal noise is caused by natural process. It is different from Gaussian process [8-12].

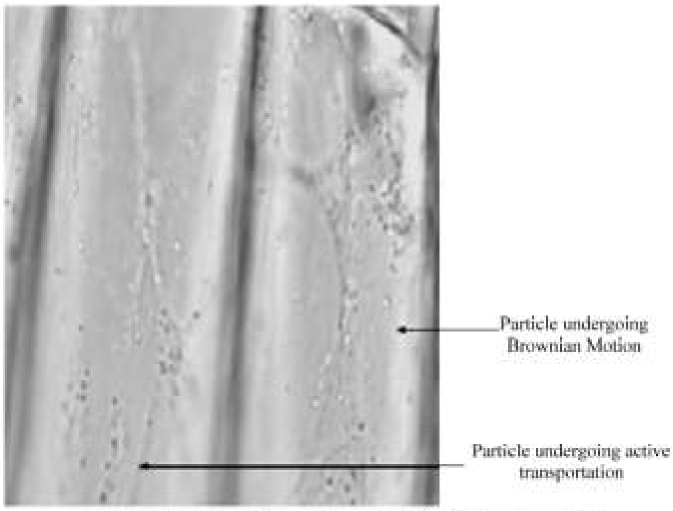

Figure 2 Visualized vesicles in onion cells (x20) form Brownian motion [10]

Although power spectrum of fractal noise, decaying continuously due to increase in frequency. Fractal noise is almost singular everywhere. A fractional Brownian motion is mathematically represents as a zero mean Gaussian process (B_H) which is showing in equation (2) and equation (3), respectively [6].

$$B_H(0) = 0 \quad (2)$$

and expected value of fractional Brownian motion is

$$E\{| B_H(t) - B_H(t-\Delta)|^2\} = \sigma^2 |\Delta|^{2H} \quad (3)$$

2.4 IMPULSE VALUED NOISE (SALT AND PEPPER NOISE)

The term impulse noise is also used for this type of noise Other terms are spike noise, random noise or independent noise. Black and white dots appear in the image as a result of this noise and hence salt and pepper noise. This noise arises in the image because of sharp and sudden changes of image signal. Dust particles in the image acquisition source or over heated faulty components can cause this type of noise. Image is corrupted to a small extent due to noise. Fig Show the effect of this noise on the original image

Figure 2.A. Original image without Noise

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Figure 2.B. Image with 30% salt & pepper noise

This is also called data drop noise because statistically its drop the original data values. This noise is also referred as salt and pepper noise. However the image is not fully corrupted by salt and pepper noise instead of some pixel values are changed in the image. Although in noisy image, there is a possibilities of some neighbours does not changed [13-14].

This noise is seen in data transmission. Image pixel values are replaced by corrupted pixel values either maximum ‘or’ minimum pixel value i.e., 255 ‘or’ 0 respectively, if number of bits are 8 for transmission.

Let us consider 3x3 image matrices which are shown in the Fig. 3. Suppose the central value of matrices is corrupted by Pepper noise. Therefore, this central value i.e., 212 is given in Fig. 3 is replaced by value zero.
In this connection, we can say that, this noise is inserted dead pixels either dark or bright. So in a salt and pepper noise, progressively dark pixel values are present in bright region and vice versa [15].

254	207	210
97	212	32
62	106	20

→

254	207	210
97	0	32
62	106	20

Figure 3 The central pixel value is corrupted by Pepper noise

Inserted dead pixel in the picture is due to errors in analog to digital conversion and errors in bit transmission. The percentagewise estimation of noisy pixels, directly determine from pixel metrics. The PDF of this noise is shown in the Fig. 4.

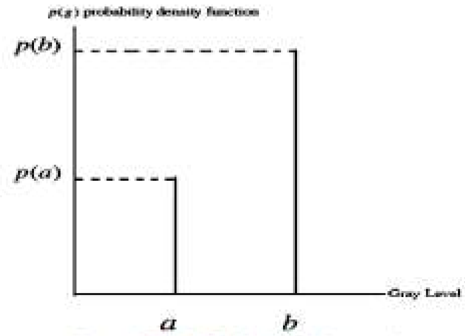

Figure 4. The PDF of Salt and Pepper noise

$$P(g) = \begin{cases} Pa \text{ for } g = a \\ Pb \text{ for } g = b \\ 0 \text{ otherwise} \end{cases} \quad (4)$$

Fig. 4 shows the PDF of Salt and Pepper noise, if mean is zero and variance is 0.05. Here we will meet two spike one is for bright region (where gray level is less) called ‘region a’ and another one is dark region (where gray level is large) called ‘region b’, we have clearly seen here the PDF values are minimum and maximum in ‘region a’ and ‘region b’, respectively [16]. Salt and Pepper noise generally corrupted the digital image by malfunctioning of pixel elements in camera sensors, faluty memory space in storage, errors in digitization process and many more.

2.5 PERIODIC NOISE

This noise is generated from electronics interferences, especially in power signal during image acquisition. This noise has special characteristics like spatially dependent and sinusoidal in nature at multiples of specific frequency. It’s appears in form of conjugate spots in frequency domain. It can be conveniently removed by using a narrow band reject filter or notch filter.

2.6 QUANTIZATION NOISE

Quantization noise appearance is inherent in amplitude quantization process. It is generally presents due to analog data converted into digital data. In this noise model, the signal to noise ratio (SNR) is limited by minimum and maximum pixel value, P_{min} and P_{max} respectively.

The SNR is given as

$$SNR_{dB} = 20 \log_{10} (P_{max} - P_{min}) / \sigma n \quad (5)$$

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Where σ_n = Standard deviation of noise, when input is full amplitude sine wave SNR becomes

$$SNR = 6n + 1.76 \text{ dB} \quad (6)$$

Where n is number of bits. Quantization noise obeys the uniform distribution. That is why it is referred as uniform noise. Its PDF is shown in Fig. 5.

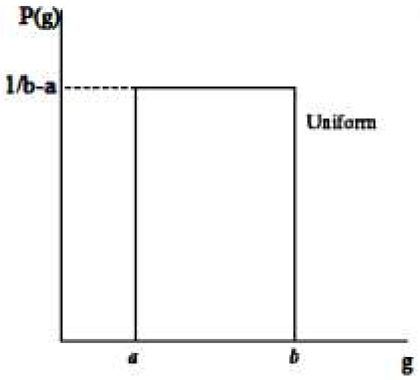

Figure 5 Uniform noise

$$P(g)=\begin{cases}\frac{1}{b-a} & \text{if } a \le g \le b\\ 0 & \text{otherwise}\end{cases} \quad (7)$$

and their mean $\mu = \frac{a+b}{2}$ and variance $\sigma^2 = \frac{(b-a)^2}{12}$

2.7 SPECKLE NOISE

This noise is multiplicative noise. Their appearance is seen in coherent imaging system such as laser, radar and acoustics etc,. Speckle noise can exist similar in an image as Gaussian noise. Its probability density function follows gamma distribution, which is shown in Fig. 6 and given as in equation (8) [17-19].

$$F(g) = \frac{g^{\alpha-1} e^{\frac{-g}{a}}}{(\alpha-1)!\, a^{\alpha}} \quad (8)$$

Figure 6 Lena image [20] of Speckle noise with variance 0.04

This noise can be modeled by random value multiplications with pixel values of the image and can be expressed as

$$J = I + n*I$$

Where, J is the speckle noise distribution image, I is the input image and n is the uniform noise image by mean o and variance v. This noise deteriorates the quality of active radar and Synthetic aperture radar (SAR) images. This noise is originated because of coherent processing of back scattered signals from multiple distributed points. In conventional radar system this type of noise is noticed when the returned signal from the object having size less than or equal to a single image processing unit, shows sudden fluctuations. Mean filters are good for Gaussian noise and uniform noise.

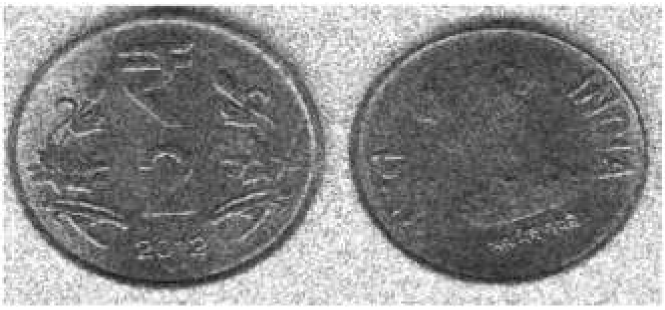

Figure 6.A.Image with speckle noise

2.8 PHOTON NOISE (POISSON NOISE)

Poisson or shot photon noise is the noise that can cause, when number of photons sensed by the sensor is not sufficient to provide detectable statistical information. This noise has root mean square value proportional to square root intensity of the image. Different pixels are suffered by independent noise values. At practical grounds the photon noise and other sensor based noise corrupt the signal at different proportions. Figure shows the result of adding Poisson noise. This noise obeys the Poisson distribution and is given as

$$P(f_{(pi)})=k)=\frac{\lambda^{k}_{i} e^{-\lambda}}{k!} \quad (9)$$

Figure 6.B.Image with Poisson noise

2.9 POISSON-GAUSSIAN NOISE

In this section the proposed model work for removing of Poisson-Gaussian noise that is arose in Magnetic Resonance Imaging (MRI). Poisson-Gaussian noise is shown in Fig. 7. The paper introduces the two most fantastic noise models, jointly called as Poisson-Gaussian noise model. These two noise models are specified the quality of MRI recipient signal in terms of visual appearances and strength [21]. Despite from the highest quality MRI processing, above model describes the set of parameters of the Poisson-Gaussian noise corrupted test image. The Poisson-Gaussian noise model can be illustrated in the following manner.

$$Z(j,k)=\alpha * P_{\alpha}(j,k)+N_{\alpha}(j,k) \quad (10)$$

Where, the model has carried Poisson-distribution (p_{α}) follows with Gaussian distribution (n_{α}). Poisson-distribution estimating using mean ($\mu_{\alpha 1}$) at given level $\alpha > 0$ and Gaussian-distribution counted at given level $\alpha > 0$ using zero mean $(\mu_{\alpha 2})$ and variance $\sigma^{2}_{\alpha 2}$. To evaluate $\mu_{\alpha 1}$, noisy Poisson image was quantitatively added to underlying original image. After all to get a noisy image $Z(j,k)$ from the Poisson-Gaussian model is based on [22-23].

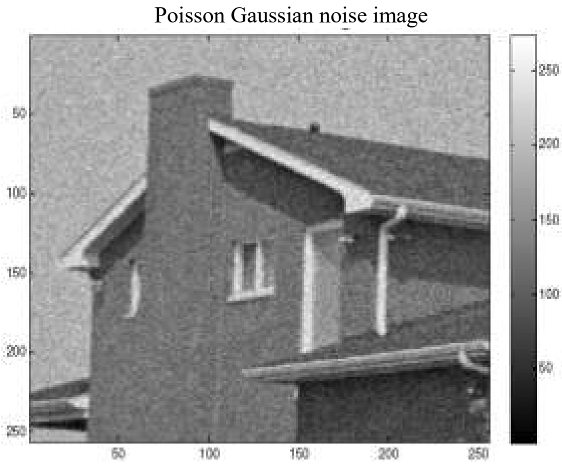

Figure 7 Poisson-Gaussian Noise House Image [20]

2.10 STRUCTURED NOISE

Structured noise are periodic, stationary or non-stationary and aperiodic in nature. If this noise is stationary, it has fixed amplitude, frequency and phase. Structured noise caused by interferences among electronic components [24]. Noise presents in communication channel are in two parts, unstructured noise (u) and structured noise (s). Structured noise is also called low rank noise. In a signal processing, it is more advantagable (more realistic) to considering noise model in a lower dimensionality space.

Further, this model is mapped into full rank measurement space in physical system. So we can conclude that in the measurement space, resulting noise has low rank and exhibits structure dependent on physical system.

Structured noise model is showing in equation (11) and equation (12), respectively [25].

$$y_{(n)} = x_{(n,m)} + v_{(n)} \quad (11)$$

$$y(n) = H(n,m) * \theta(m) + S(n,t) * \varphi(t) + v(n) \quad (12)$$

Where, n = rows, m = columns, y = received image, H = Transfer function, of linear system, S = Subspace, t = rank in subspace, φ = underlying process exciting the linear system (S), θ = signal parameter sets initial conditions or excites, linear system H is used to produce original signal x in terms of n vector random noise ($v_{(n)}$) .

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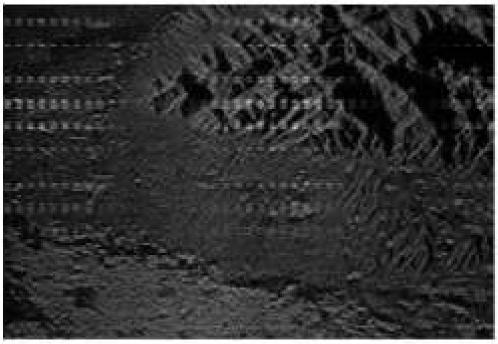

Figure 8 Structured Noise
(when noise is periodic and non stationary) [25]

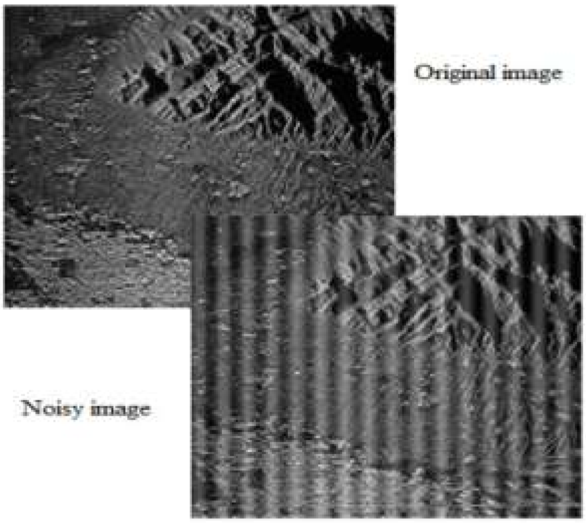

Figure 9 Structured Noise [25]

2.11 GAMMA NOISE

Gamma noise is generally seen in the laser based images. It obeys the Gamma distribution. Which is shown in the Fig. 10 and given as [26-27]

$$P(g) = \begin{cases} \frac{a^b g^{b-1} e^{-ag}}{(b-1)!} & \text{for } g \geq 0 \\ 0 & \text{for } g < 0 \end{cases} \quad (13)$$

Where mean $\mu = \frac{b}{a}$ and variance $\sigma^2 = \frac{b}{a^2}$ are given as, respectively.

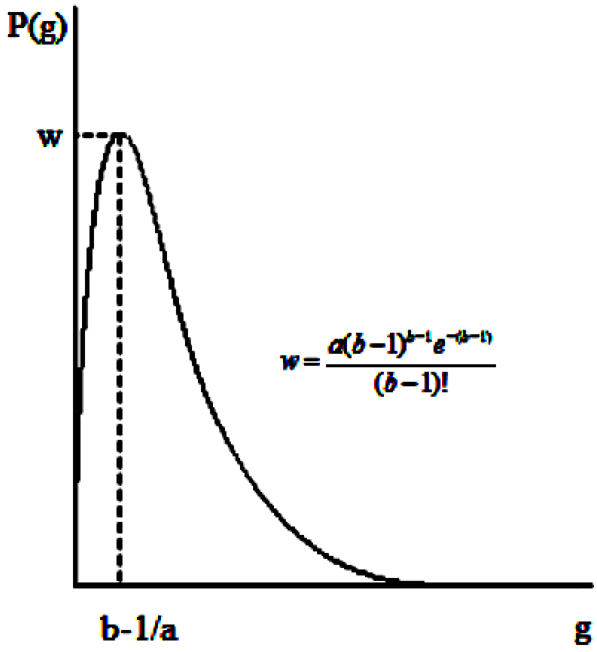

Figure 10 Gamma distribution

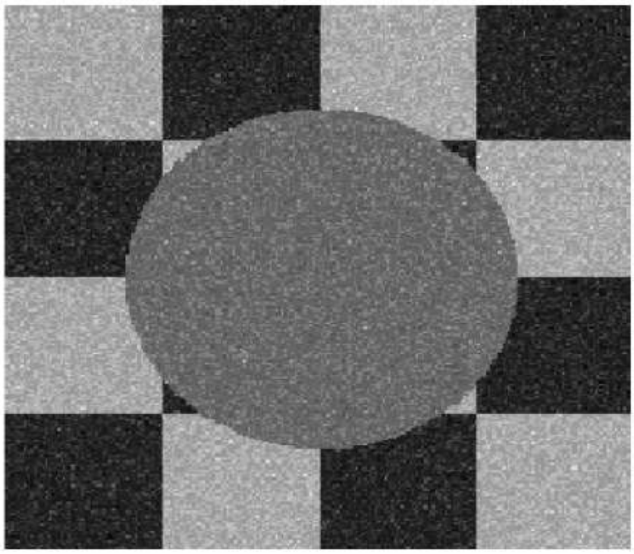

Figure 11 Gamma Noise [26]

2.12 RAYLEIGH NOISE

Rayleigh noise presents in radar range images. In Rayleigh noise, probability density function is given as [26].

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$$P(g)=\begin{cases}\frac{2}{b}(g-a)e^{\frac{-(g-a)^2}{b}} & \text{for } g \geq a\\ 0 & \text{for } g < a\end{cases} \quad (14)$$

Where mean $\mu = a + \sqrt{\frac{\pi b}{4}}$ and variance $\sigma^2 = \frac{b(4-\pi)}{4}$ are given as, respectively.

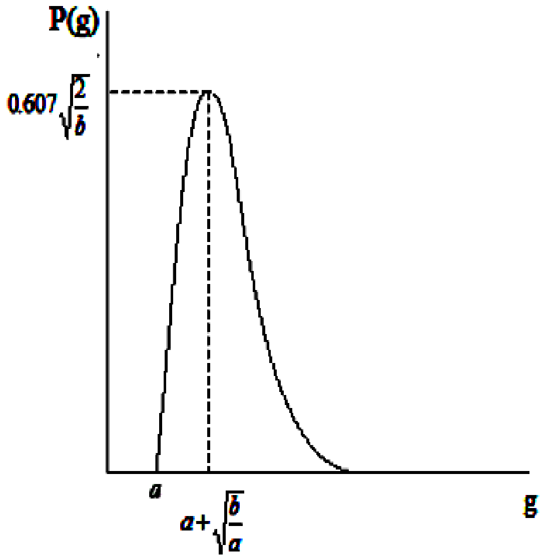

Figure 12 Rayleigh distribution

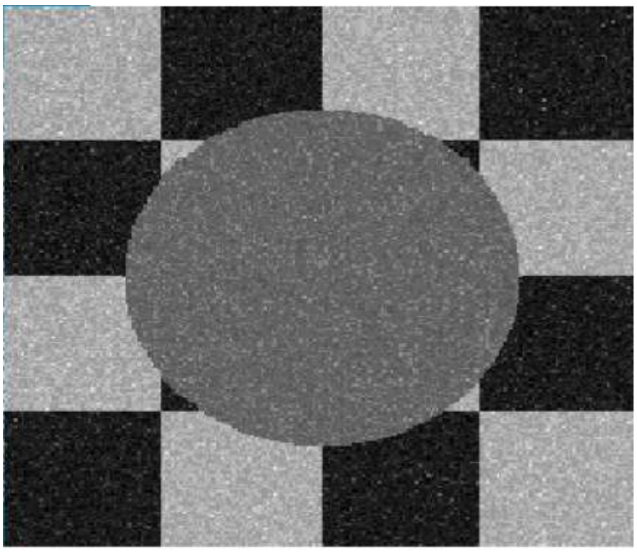

Figure 13 Rayleigh Noise [26]

III. IMAGE DE-NOISING

Image de-noising is very important task in image processing for the analysis of images. Ample image de-noising algorithms are available, but the best one should remove the noise completely from the image, while preserving the details. De-noising methods can be linear as well as non-linear. Where linear methods are fast enough, but they do not preserve the details of the images, whereas the non- linear methods preserve the details of the images. Broadly speaking, De-noising filters can be categorized in the following categories:

- Averaging filter
- Order Statistics filter
- Adaptive filter

A. Mean filter

Mean filter is an averaging linear filter. Here the filter computes the average value of the corrupted image in a pre-decided area. Then the center pixel intensity value is replaced by that average value. This process is repeated for all pixel values in the image. Fig 14-Fig 15, show the effect of using mean filter of size 5X5 on different types of noise.

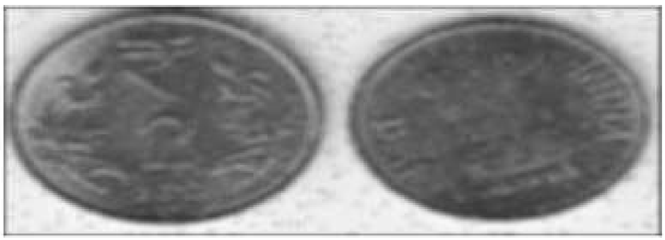

Figure 14 Mean filter used on Salt pepper noise

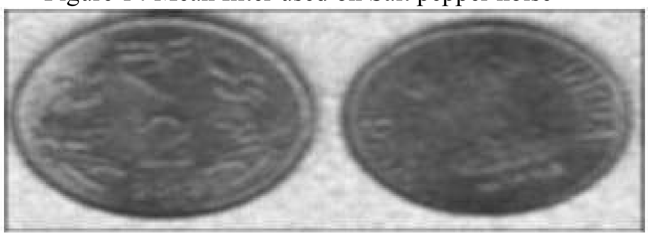

Figure 15 Mean filter used for Speckle noise

B.Median Filter

Median filter is a best order static, non- linear filter, whose response is based on the ranking of pixel values contained in the filter region. Median filter is quite popular for reducing certain types of noise. Here the center value of the pixel is replaced by the median of the pixel values under the filter regio. Fig 16-Fig 17 show the effect of median filter on different types of noise.

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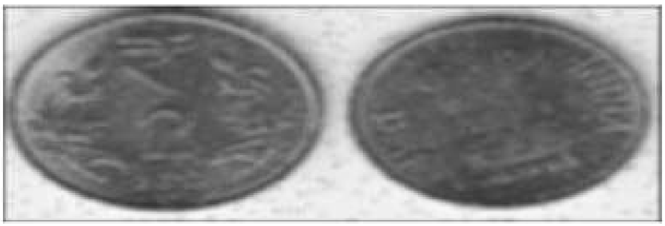

Figure 16 Mean filter used on Salt pepper noise

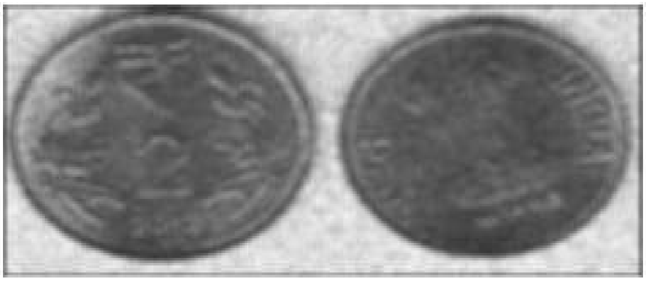

Figure 17 Mean filter used for Speckle noise

Median filter is good for salt and pepper noise. These filters are widely used as smoothers for image processing, as well as in signal processing. A major advantage of the median filter over linear filters is that the median filter can eliminate the effect of input noise values with extremely large magnitudes.

C. Order Statistics Filter

Order-Statistics filters are non-linear filters whose response depends on the ordering of pixels encompassed by the filter area. When the center value of the pixel in the image area is replaced by 100^{th} percentile, the filter is called max-filter. On the other hand, if the same pixel value is replaced by 0^{th} percentile, the filter is termed as minimum filter. Fig. 18-Fig 19 will present the result of using minimum order static filter

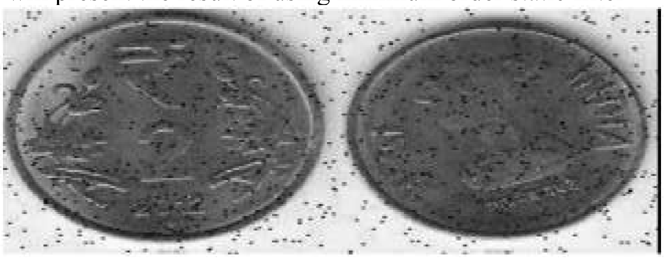

Figure 18 Order Static (minimum) filter used for Salt and pepper noise

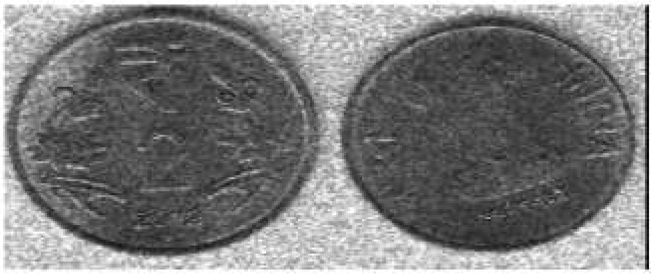

Figure 19 Order Static (minimum) filter used for Speckle noise

D. Adaptive Filter

These filters change their behavior on the basis of statistical characteristics of the image region, encompassed by the filter region.BM3D is an adaptive filter. It is a nonlocal image modeling technique based on adaptive, high order group-wise models. This de-noising algorithm can be divided in three steps. 1. Analysis. Firstly similar image blocks are collected in groups. Blocks in each group are stacked together to form 3-D data arrays, which are de-correlated using an invertible 3D transform. 2. Processing. The obtained 3-D group spectra are filtered by hard thresholding. 3. Synthesis. The filtered spectra are inverted, providing estimates for each block in the group. These block-wise estimates are returned to their original positions and the final image reconstruction is calculated as a weighted average of all the obtained block-wise estimates. The results of applying BM3D algorithm is presented in the Fig 20-Fig 21

Figure 20 BM3D filter used for Salt and pepper noise

Figure 21 BM3D filter used for Speckle noise

IV. CONCLUSIONS

In this paper, we have discussed different types of noise that creep in images during image acquisition or transmission. Light is also thrown on the causes of these noises and their major sources. In the second section we present the various filtering techniques that can be applied to de-noise the images. Experimental results presented, insists us to conclude that BM3D and median filters performed well. Whereas averaging and minimum filters performed worst. BM3D is the best choice of removing the Salt and pepper noise. Whereas in other cases median filter is more suitable.

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