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Effect of different types of Noise on the Quality of Images

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Abstract--- Images are prone to different types of noises during their acquisition or transmission. Any type of noise degrades the quality of the image. The present work makes a comparative study on the effect of different types of noise such as Gaussian noise, Poisson noise, Salt & Pepper noise and Speckle noise on the quality of the images. Mean squared error and Peak signal-to-noise ratio have been considered as parameters for assessing the quality of the images. The results obtained show that the Poisson noise has less corrupting effect on the quality of the image and the Salt and Pepper noise has more corrupting effect on the quality of the image. The results obtained also show that the increasing order of corrupting effect of different types of noise is Poisson noise, Gaussian noise, Speckle noise and Salt and Pepper noise.

Index terms--- Gaussian Noise, Poisson Noise, Salt & Pepper Noise, Speckle Noise, Quality of Image

I.INTRODUCTION

An image may be defined as a two dimensional function, $f(x,y)$, where x and y are spatial coordinates and the amplitude of f at any pair of coordinates (x,y) is called the intensity of the image at that point. Noise in an image refers to any degradation caused in an image signal. The sources of noise in digital images arise during image acquisition and transmission. A noisy image can be modeled as $g(x,y)=f(x,y)+n(x,y)$ where $f(x,y)$ is the original image pixel, $n(x,y)$ is the noise term and $g(x,y)$ is the noisy image pixel. The different models for noise term $n(x,y)$ are Gaussian, Rayleigh, Erlang, Exponential, Uniform, Poisson etc. Gaussian noise is statistical noise having a probability density function equal to that of the normal distribution.

The probability density function p of a Gaussian random variable z is given by $p(z)=\frac{1}{\sigma\sqrt{2\Pi}}e^{\frac{-(z-\mu)^2}{2\sigma^2}}$ where z represents the gray level, μ represents Mean value and σ represents Standard Deviation. Poisson noise is a basic form of uncertainty associated with the measurement of light, inherent to the quantized nature of light and the independence of photon detections. Individual photon detections can be treated as independent events that follow a random temporal distribution. As a result, photon counting is a classic Poisson process and the number of photons N measured by a given sensor element over time interval t is described by the discrete probability distribution $\Pr(N=k)=\frac{e^{-\lambda t}(\lambda t)^k}{k!}$ where λ is the expected number of photons per unit time interval. This is a standard Poisson distribution with a rate parameter λt that corresponds to the expected incident photon count. Salt and pepper noise presents itself as sparsely occurring black and white pixels. Speckle is a granular 'noise' that inherently exists in and degrades the quality of the active radar, synthetic aperture radar (SAR), medical ultrasound and optical coherence tomography images. Mean squared error and Peak signal-to-noise ratio have been considered as parameters for assessing the quality of the images.

Mean Squared Error (MSE) is defined as the cumulative squared error between the original image and the noise corrupted image. It is given by the following formula.

$$MSE=\frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left[I(i,j)-K(i,j)\right]^2$$

where $I(i,j)$ is the original image and $K(i,j)$ is the noise corrupted image.

Peak Signal-to-Noise Ratio (PSNR) is defined as the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is measured in decibels. It is given by the following formula.

$$PSNR=10\log 10\left[\frac{MAX_I^2}{MSE}\right]$$

where MAX_I is the maximum possible pixel value of the image and MSE is the Mean Squared Error.

II. EXPERIMENTAL WORK AND RESULTS

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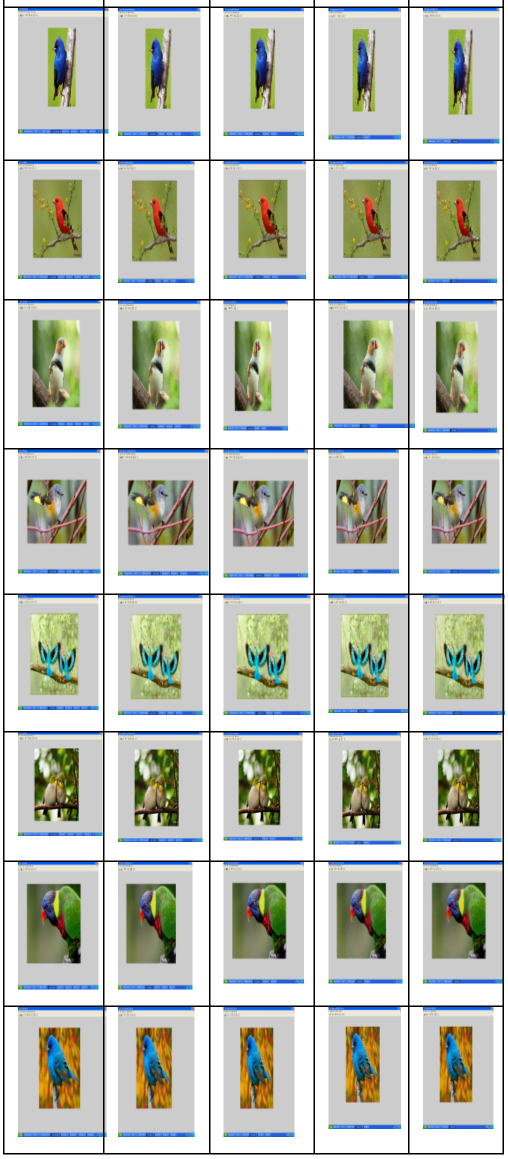
Images of different sizes (226×259 pixels, 652×409 pixels, 700×476 pixels, 928×370 pixels, 1024×683 pixels, 1024×768 pixels, 1200×627 pixels, 1600×1200 pixels, 1920×1080 pixels) have been considered and then they are corrupted with Gaussian noise, Poisson noise, Salt & Pepper noise and Speckle noise. The original image and then the noise corrupted images have been tabulated for visual discrimination. Mean Squared Error between the original image and the images corrupted with different types of noise has been calculated and tabulated. Similarly, Peak Signal-to-Noise Ratio between the original image and the image corrupted with different types of noise has also been calculated and tabulated.

TABLE 1: ANALYSIS OF THE QUALITY OF IMAGES AFTER CORRUPTING WITH DIFFERENT TYPES OF NOISE

Original Image	Gaussian Noise Corrupted Image	Poisson Noise Corrupted Image	Salt and Pepper Noise Corrupted Image	Speckle Noise Corrupted Image



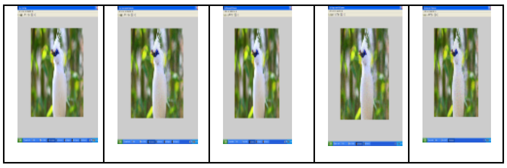


TABLE 2: ANALYSIS OF MEAN SQUARED ERROR OBTAINED BETWEEN THE ORIGINAL IMAGE AND THE CORRUPTED IMAGES DUE TO DIFFERENT TYPES OF NOISE

	Size of the image in pixels	MSE between original image and Gaussian Noise corrupted image	MSE between original image and Poisson Noise corrupted image
Image-1	226×259	0.0092	4.5188E-013
Image-2	652×409	0.0096	4.2970E-013
Image-3	700×476	0.0095	5.0470E-013
Image-4	928×370	0.0096	4.6162E-013
Image-5	1024×683	0.0093	5.9188E-013
Image-6	1024×768	0.0086	3.6349E-013
Image-7	1200×627	0.0092	3.3749E-013
Image-8	1600×1200	0.0085	3.7588E-013
Image-9	1920×1080	0.0094	4.7810E-013

TABLE 2: CONTINUED

	Size of the image in pixels	MSE between original image and Salt & Pepper Noise corrupted image	MSE between original image and Speckle Noise corrupted image
Image-1	226×259	0.0162	0.0125
Image-2	652×409	0.0145	0.0107
Image-3	700×476	0.0152	0.0137
Image-4	928×370	0.0146	0.0120
Image-5	1024×683	0.0158	0.0179
Image-6	1024×768	0.0173	0.0090
Image-7	1200×627	0.0156	0.0072
Image-8	1600×1200	0.0171	0.0098
Image-9	1920×1080	0.0155	0.0126

TABLE 3: ANALYSIS OF PEAK SIGNAL-TO-NOISE RATIO OBTAINED BETWEEN THE ORIGINAL IMAGE AND THE CORRUPTED IMAGES DUE TO DIFFERENT TYPES OF NOISE

	Size of the image in pixels	PSNR between original image and Gaussian Noise corrupted image	PSNR between original image and Poisson Noise corrupted image
Image-1	226×259	68.4830	171.5806
Image-2	652×409	68.2986	171.7992
Image-3	700×476	68.3471	171.1005
Image-4	928×370	68.2950	171.4879
Image-5	1024×683	68.4311	170.4084
Image-6	1024×768	68.7905	172.5259
Image-7	1200×627	68.4837	172.8482
Image-8	1600×1200	68.8140	172.3803
Image-9	1920×1080	68.3896	171.3356

TABLE 3: CONTINUED

	Size of the image in pixels	PSNR between original image and Salt & Pepper Noise corrupted image	PSNR between original image and Speckle Noise corrupted image
Image-1	226×259	66.0300	67.1624
Image-2	652×409	66.5091	67.8208
Image-3	700×476	66.3142	66.7778
Image-4	928×370	66.5016	67.3503
Image-5	1024×683	66.1496	65.6017
Image-6	1024×768	65.7499	68.6005
Image-7	1200×627	66.1967	69.5546
Image-8	1600×1200	65.7973	68.2109
Image-9	1920×1080	66.2184	67.1156

From the results obtained, it is clearly evident that the Mean squared error obtained from the Poisson noise corrupted image and their corresponding original image is less and hence the quality of these images is high. As the Mean squared error obtained from the Salt and pepper Noise corrupted images and their corresponding original images is high, the quality of these images is low.

III.CONCLUSION

Images are often affected by different types of noise such as Gaussian noise, Poisson noise, Salt and pepper noise, speckle noise etc. The present work has performed a comparative study among different types of noise such as Gaussian noise, Poisson noise, Salt & Pepper noise and Speckle noise on the quality of images. As the Mean squared error obtained from the Poisson noise corrupted image and the original image is less, it has less corrupting effect on the quality of the image. As the Mean squared error obtained from the Salt & pepper noise corrupted image and the original image is high, it has more corrupting effect on the quality of the image. It is also evident that the increasing order of corrupting effect of different types of noise is Poisson noise, Gaussian noise, Speckle noise and Salt and Pepper noise.

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