Introduction to Image Restoration

Amit Kumar Sharma[1], Kapil Sachan[2], Kajol Gupta[3]

[1]Asst. Prof., Dept. of Computer Science and Engg., Babu Banarasi Das Institute of Technology Ghaziabad, India
[2,3]Student, Dept. of Computer Science and Engg., Babu Banarasi Das Institute of Technology Ghaziabad, India

Abstract: **Image Restoration is one of the technique used in various fields to reduce the degradation in the image occurred during the image acquisition. Image restoration has become popular topic in academics due to its increasing growth and promising application and efficient services. Understanding the current status of image restoration research area is a must to maintain the advancement of knowledge in image restoration research and to examine the gap between theory and live experiments. In this paper, we present a literature review on Image Restoration technology.**

Keywords: **Image restoration**

1. Introduction

There was time where we need to have separate photographer for any trip or any special function or casual parties. But now everyone has their personal phones with them with high quality camera.

You can buy good camera with money but not the talent of the photographer. Sometimes image captured loses its quality and miss some of the original attributes of the image. The aim of restoration is to bring the image what would it have been recorded without degradation. Restoration tries to do the objective approach process, in this we have the prior knowledge of degradation done. Restoration hence deals with getting an optimal estimate of the original image.

Image restoration apps are widely available in the various app market, user interface of these applications are very easy and easy to operate on common use. Due to simplicity it has become exciting topic for some of the beginners. There are some other applications that are used by professionals to find out missing part of much complex images.

Scope: Image Restoration has been interesting topic in the academics as well as in professional areas. It has a very emerging future and a nice career to professionals. It has wide areas to cover and could be altered in any fields.

2. Theoretical Considerations

A. Difference from image enhancement

In image enhancement the image is not degraded or lost, in enhancement the image quality is improved by adjusting its colors, saturation, and other different attribute that are to be adjusted to give the image a nice and better look. Image enhancement is a subjective process to amplify the quality of the image.

B. Steps done for restoration

Theoretically the things that happens when an image is been distorted, reverse thing is done to restore the image.

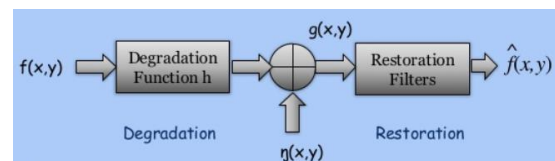Process of degradation of an image is shown by one image.

Fig. 1. Process of degradation of an image

In here the image is represented by the function f(x,y) is passed through the degradation function and additive noise is also captured during the image acquisition process so noise function n(x,y) is also added to the value. Now after all this things a final degraded image is formed and that is termed as g(x, y).

Now to restore that degraded image g(x,y) it is passed through restoration filter. The restored image will differ from the original image, original cannot be formed through distorted image it can reach up to near to original.

C. Noise and Noise Models

In an image, noise is random change in brightness or any other color information, usually aspect of electronic noise. It can be produced by the image acquisition, particularly by the camera or any sensor. Noise cannot be predicted earlier, they are totally undesirable by-product of image capturing.

Noise can range from light or small noise such as an image taken from digital camera to image full of noise for example image taken from old phones.

To understand this noise we need to understand the noise models.

Noise Model:

Image get corrupted by noise during acquisition or during transmission. For better understanding of the restoration process, we first need to understand the noise function n(x,y). If we have good restoration system then only we could have realistic noise models. In an imaging system, noise can either be additive or multiplicative.

Noise models can be assumed as:
1. Independent of spatial coordinates.
2. Uncorrelated with the image. (no correlation between noise components and the pixel values)

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Noise models are of following types:
1. Gaussian noise (normal)
2. Rayleigh noise
3. Gamma noise (Erlang noise)
4. Exponential noise
5. Salt and Pepper noise (Impulse)
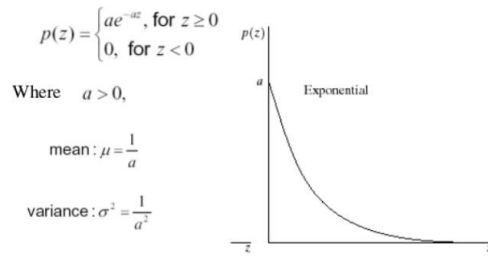6. Uniform noise
7. Sinusoidal noise

1) Gaussian Model

Gaussian model is simple as it provides a good model of noise. These are very popular at times when the other entire model fails.

$$p(z) = \frac{1}{\sqrt{2\pi}\sigma} e^{-(z-u)^2/2\sigma^2}$$

z: gray level
μ: mean of random variable z
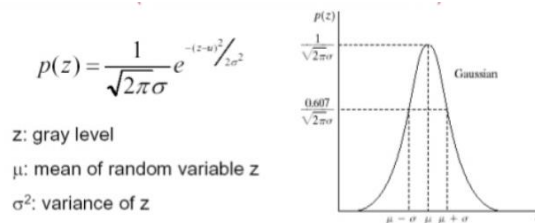σ^2: variance of z

Fig. 2. Gaussian model

This particular model is very popular amongst all above mentioned noise models because of it is easy to implement and very easy to understand due to the symmetry of the graph.

2) Rayleigh Noise

Rayleigh model is not symmetric like the Gaussian model. The plot of the Rayleigh distribution can be shown as:

$$p(z) = \begin{cases} \frac{2}{b}(z-a)e^{-(z-a)^2/b} & for \quad z \geq a \\ 0 & for \quad z < a \end{cases}$$

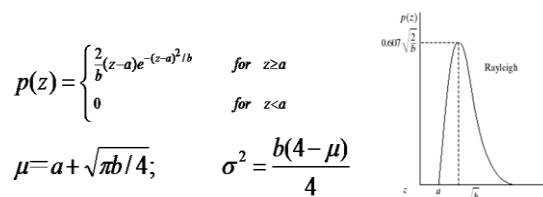$$\mu = a + \sqrt{\pi b/4}; \qquad \sigma^2 = \frac{b(4-\mu)}{4}$$

Fig. 3. Rayleigh Noise

3) Gamma Noise (Erlang noise)

Gamma noise is similar to Rayleigh distribution.
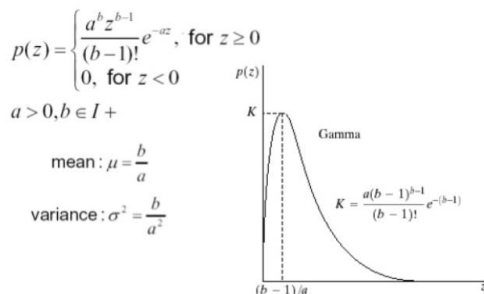Gamma noise distribution always starts from zero.

$$p(z) = \begin{cases} \frac{a^b z^{b-1}}{(b-1)!} e^{-az}, & for \ z \geq 0 \\ 0, & for \ z < 0 \end{cases}$$

$a > 0, b \in I +$

$$mean: \mu = \frac{b}{a}$$

$$variance: \sigma^2 = \frac{b}{a^2}$$

$$K = \frac{a(b-1)^{b-1}}{(b-1)!} e^{-(b-1)}$$

Fig. 4. Gamma Noise (Erlang noise)

4) Exponential Noise

Exponential noise has exponential shape.

$$p(z) = \begin{cases} ae^{-az}, & for \ z \geq 0 \\ 0, & for \ z < 0 \end{cases}$$

Where $a > 0$,

$$mean: \mu = \frac{1}{a}$$

$$variance: \sigma^2 = \frac{1}{a^2}$$

Fig. 5. Exponential Noise

5) Salt and Pepper noise(impulse)

These types of noise appear as black and white dots on the entire image.

$$p(z) = \begin{cases} P_a & for \ z = a \\ P_b & for \ z = b \\ 0 & otherwise \end{cases}$$
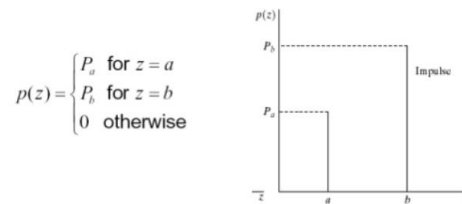
If either $P_a = 0$ or $P_b = 0$ ⟹ unipolar impulse noise
If $P_a \approx P_b \neq 0$ ⟹ bipolar impulse noise or salt-and-pepper noise ⟹ normally, a=0 (black) and b=255 (white)

Fig. 6. Salt and Pepper noise(impulse)

6) Uniform Noise

This type of noise is uniform over a certain band of grey levels.

$$p(z) = \begin{cases} \frac{1}{b-a}, & if \ a \leq z \leq b \\ 0 & otherwise \end{cases}$$

The mean and variance are given by

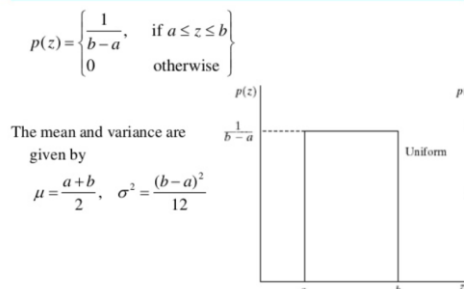$$\mu = \frac{a+b}{2}, \quad \sigma^2 = \frac{(b-a)^2}{12}$$

Fig. 7. Uniform Noise

7) Sinusoidal Noise

In the sinusoidal noise, images are usually corrupted by periodic noise due to electrical and electromechanical interface during acquisition.

3. Applications

Image restoration is a technique used in various fields. Nowadays, there are many fields related to the image, such as Medical Science, Construction site, Forensic Science etc.

A. Medical Science Field

Due to some reasons like in MRI and CT Scan there is need for a lot of precision and perfection for that, in the device there is an inbuilt feature to automatically detect the disturb images. Moreover, if we move towards the genetics and microorganism the images should be of less degradation and there should be

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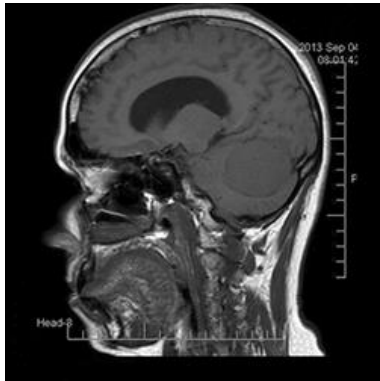less probability of distortion.

Fig. 8. Medical science field (MRI and CT Scan)

B. Construction Site

In construction site there is lot of work of imaging, minor mistakes can lead up to huge loss of time and misleading of the running project, therefore there should be someone to ensure that the image should be free from distortion and the project should look like as it is in original site.

Fig. 9. Construction site

C. Forensic Science Field

Fig. 10. Forensic Science Field

Forensic experts need to cover all the clue and evidence that are required to solve the cases. Sometimes they found corrupt images and they need to find out what would be actual image look like.

Moreover, there are several things that could be related to this field and image restoration. Certain things that could be listed is facial matching through Artificial intelligence. Image restoration could be implemented through artificial intelligence to extend its use to maximum possibilities.

4. Conclusion

This paper presented an overview on image restoration.

References

[1]   https://en.wikipedia.org/wiki/Image_restoration