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A Survey on Image Restoration Techniques with Noise Models

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***Abstract*— Image restoration is the process of improving the appearance of the Digital Image. Image restoration is used to estimate the original image from the degraded data. The aim of this paper is introduced Digital Image Restoration. This paper will discussed about various types of noises, blind and non-blind Image Restoration Technique and applications of Image Restoration.**

I. INTRODUCTION

In recent years, the most active area in Digital Image Processing is of Image restoration. Here, the original image is restored from the degraded once. Here, we first take an image which is known as original image [3]. The process of image restoration is divided into two phases named as

- Degradation Phase and
- Restoration Phase

Degradation Phase:

In this phase, the original image is degraded with a degradation function and an additive noise. The resultant image of this phase is a degraded image.[2]

Restoration Phase:

In this phase, the degraded image is restored using various restoration filters and an estimated image of the original image is produced as an output

Degradation Model

Distortion is almost always involved in recorded images. Distortion is mainly because of imperfection in the imaging system.[2]

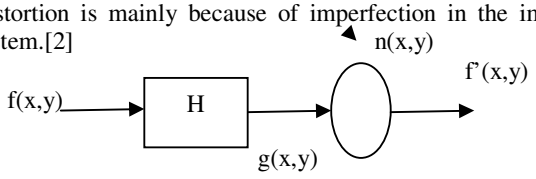


Fig 1: Degradation Model

Degradation operation works on input image f(x, y) to lessen a degraded image g(x, y). With g(x, y) some information of the degradation function H and information about the noise term also get added, the aim of image restoration is to obtain an estimate f'(x, y) of the original image f(x, y).

Image Restoration methods can be divided into two classes:

- Blind
- Non Blind

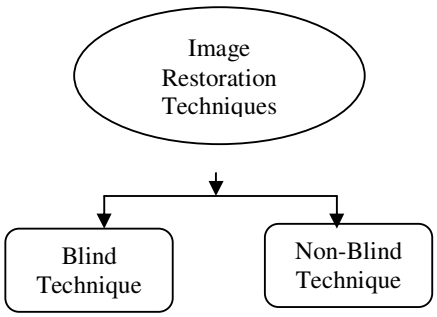
Blind Technique:

Blind Restoration is the one in which the blurring operator is unknown, we have to make an estimate of the blurring operator and then using that estimate we have to deblur the image.

Non-Blind Technique:

The Non Blind Restoration is the one in which the blurring operator is known, we can easily remove blur from the degraded image using the knowledge of blurring function.

Broadly, Image restoration techniques are classified into two categories which are shown in Figure 2 below:[7]



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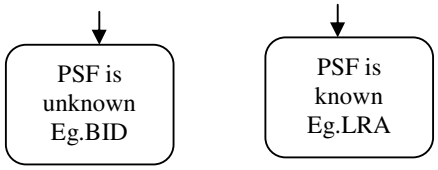

BID – Blind Image Deconvolution
LRA – Lucy Richardson Algorithm

II. Noise Models

The Principal sources of Noise in digital Images arise during image acquisition or transmission. For example, an image transmitted using a wireless network might be corrupted as a result of lightning or other atmospheric disturbance.
The degradations may be due to [2]

- The degradation may occur due to sensor noise
- The degradations may Blur due to camera misfocus
- The degradation may occur due to relative object-camera motion
- The degradation may occur due to random atmospheric turbulence
- The degradation may occur due to some other reasons also.

III. Types Of Image Noise

The following are some of the most common Noise found in image processing applications.

Gaussian Noise

Gaussian noise is caused by random fluctuations in the signal. It's modeled by random values added to an image.

- **The PDF of a Gaussian noise is given by**

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

Rayleigh Noise:

- **The PDF of a Rayleigh noise is given by**

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

The mean and variance are given

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

Gamma Noise:

The PDF of a Gamma noise is given by

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

The mean and variance are given

$$\mu=\frac{b}{a}\qquad \sigma^2=\frac{b}{a^2}$$

Exponential Noise:

The PDF of a Exponential noise is given by

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

The mean and variance are given

$$\mu=\frac{1}{a}\qquad \sigma^2=\frac{1}{a^2}$$

Note: It is a special case of Erlang PDF , with b=1.

Uniform Noise:

The PDF of a uniform noise is given by

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

The mean and variance are given

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

Salt and Pepper Noise:

The PDF of a(bipolar) impulse noise is given by

$$p(z)=\begin{cases}P_a & for\ z=a\\ P_b & for\ z=b\\ 0 & otherwise\end{cases}$$

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It also known as impulse noise. This noise can be caused by sharp and sudden disturbances in the image signal. Its appearance is randomly scattered white or black (or both) pixel over the image.

Speckle Noise:

Speckle noise can be modeled by random values multiplied by pixel values of an image.

Periodic Noise:

Periodic noise is appearance when signal is subject to a periodic, rather than a random disturbance.[1]

The below figure are some important Noise Probability Density functions:

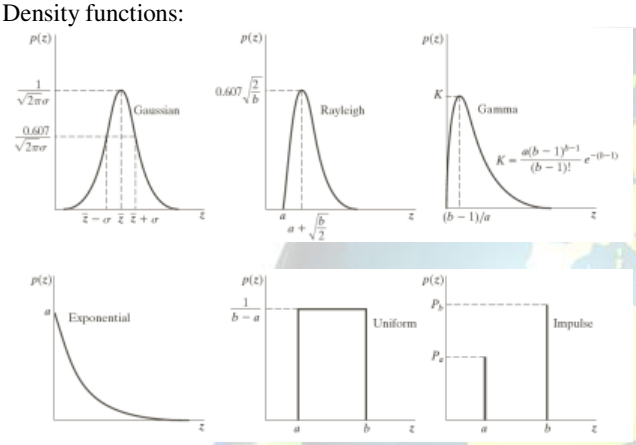

FIG 2 SOME IMPORTANT PROBABILITY DENSITY FUNCTIONS

IV. COLOURS OF NOISE

- White Noise
- Pink Noise
- Brownian Noise
- Grey Noise

White Noise

In signal processing, white noise is a random signal with a constant power, spectral Density. White noise refers to a statistical models for signals and signals sources, rather than to any specific signal.

Pink Noise

There is equal energy in all octaves (or similar log bundles) of frequency. In terms of power at a constant band with, pink noise falls off at 3db per octave.

Brownian Noise

In science, Brownian noise, also known as brown noise or red noise, is the kind of signal noise produced by Brownian motion. Hence, its alternative name of random walk noise. The term "Brown Noise" comes not from the colour, but after Robert Brown, the discoverer of Brownian motion.

Grey Noise:

Grey noise is random noise subjected to a psychoacoustic equal loudness curve (such as an inverted a – weighting curve) over a given range of frequencies, giving the listener the perception that is equally loud at all frequencies.

V. CONCLUSION

The main objective of this work is to carry out a comparative study to evaluate the performance of various image restoration and various noises and its colour to develop a restoration technique.

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