FRACTAL IMAGE COMPRESSION OF NOISY IMAGES

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Chapter 5

FRACTAL IMAGE COMPRESSION OF NOISY IMAGES

5.1 Introduction:

In many of the image storage and transmission applications, the data to be compressed is corrupted by noise. For example, in medical imaging, emission and transmission tomography images are usually corrupted by data dependent Poisson noise. Images scanned from photographic films are corrupted by data dependent film-grain noise while scanning. Noise degrades the performance of the image compression algorithms [87] [92]. Some noisy source coding algorithms used spatial prefiltering for reducing the effect of noise [87] [93].

In this Chapter, impact of film-grain noise on Fractal Image Compression is demonstrated. The focus of this Chapter is on Fractal Image Compression of film-grain noise corrupted images.

5.2 Effect of Noise on Image Compression:

Images are, in many cases, degraded even before they are encoded. Noise degrades the performance of image compression algorithms. There are two main reasons for this: noise reduces the interpixel correlation of an image, and extra bits are spent for coding noise which is in fact not a required information. Noise decreases the compression ratio. This is because, noise reduces interpixel correlation.

5.3 Fractal Image Compression of Noisy Images corrupted by Film-Grain Noise:

For demonstrating the effect of noise on Fractal Image Compression, images corrupted by data dependent film-grain noise are used. Film-grain type of noise is data
dependent and it occurs when scanning an image recorded on photographic films. In the exposure and development of a photographic film, silver halide grains that are exposed to a sufficient quantity of light are converted to grains of metallic silver. This process is not entirely deterministic, silver halide grains experiencing equivalent exposures are not necessarily converted to the same size and shape silver grains. Furthermore, silver grains are randomly distributed over the surface of the film. This inherent randomness in silver grain formation is called film-grain noise. This leads to a randomness or uncertainty in the amount of light passing or reflected from a print [85].

An observed image corrupted by film-grain noise can be modeled as

\[ g(x,y) = f(x,y) + f(x,y)n(x,y) \]  \hspace{1cm} (5.1)

where \( n(x,y) \) is a random zero mean data independent Gaussian noise with

\[ E\{n(x_1,y_1)n(x_2,y_2)\} = \sigma^2 \cdot (x_1-x_2,y_1-y_2), \quad \forall (x_1,y_1),(x_2,y_2) \]

\( f(x,y) \) is the original image, and \( \sigma \) is a constant between 1/3 and 1/2.

To study the effect of noise on Fractal Image Compression, images corrupted by film-grain noise are used. Fisher's quadtree algorithm [Ch.3, 43], Partial distance based Fractal Image Compression [90], Section 3.10, and local Fractal dimension based classification in Fractal Image Compression algorithm given in Section 3.11 are used to study the effects of noisy images.

5.3 Results for Fractal Image Compression of film-grain noise corrupted images

The standard 8-bit images of size 256x256 and 512x512 corrupted by film-grain noise are used for evaluating the performance of Fractal Image Compression algorithms, viz, Fisher's quadtree algorithm [Ch.3, 43], Partial distance based Fractal Image Compression [90], and local Fractal dimension based classification in Fractal Image Compression algorithm (given in Section 3.10) at various bit rates. Noisy
images are obtained by using Eqn.(5.1) with $\sigma^2 = \{2.0, 4.0, 16.0\}$ and $= 0.5$. $\sigma^2$ and are assumed to be known. Results are given for images lenna of size 256x256 and collie of size 256x256. The results are compared with original images. Results are tabulated in tables 5.1 –5.2 for both original and noisy image cases. Compression Ratio Versus PSNR is plotted for lenna and collie images and is shown in Figure 5.1 –5.6. It is observed that at low compression ratio, reduction in PSNR for compressed noisy image is more. It is less at high compression ratio. PSNR for noisy image when computed with respect to original image is close to the value computed for method which uses original image as input. Also it can be seen that at same PSNR, compression ratio decreases for noisy images. Changing noise level doesn’t change the general characteristics of the curves. The noisy images at various maximum levels and the decoded images are shown in Figures 5.6 – 5.8. The quality of the images can be improved by pre-filtering the input noisy image.

<table>
<thead>
<tr>
<th>Compr. Ratio</th>
<th>PSNR (in dB)</th>
<th>Original</th>
<th>Noisy Image $\sigma^2 = 2$</th>
<th>Noisy Image $\sigma^2 = 4$</th>
<th>Noisy Image $\sigma^2 = 16$</th>
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Table 5.1 Results for Noisy lenna image of size 256x256 compressed with Fisher’s Quadtrees method
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<tr>
<th>Compr. Ratio</th>
<th>PSNR (in dB)</th>
<th>Original</th>
<th>Noisy Image $\sigma_z^2 = 2$</th>
<th>Noisy Image $\sigma_z^2 = 4$</th>
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Table 5.2 Results for Noisy lenna image of size 256x256 compressed with LFD based FIC

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<th>Compr. Ratio</th>
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<th>Original</th>
<th>Noisy Image $\sigma_z^2 = 2$</th>
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Table 5.3 Results for Noisy lenna image of size 256x256 compressed with Partial Distance FIC method
Figure (5.1) Performance graph for lenna image of size 256x256 corrupted by film-grain noise with $\sigma^2 = 2$ (Fisher's method)

Figure (5.2) Performance graph for lenna image of size 256x256 corrupted by film-grain noise with $\sigma^2 = 4$ (Fisher's method)
Fisher's method for Noisy image, PSNR computed wrt noisy image
- Fisher's method for Noisy image, PSNR computed wrt original
- Fisher's method for original image

Figure(5.3) Performance graph for lenna image of size 256x256 corrupted by film-grain noise with $\sigma^2 = 16$ (Fisher's method)

Partial distance FIC for Noisy image, PSNR computed wrt Noisy image
- Partial distance FIC for Noisy image, PSNR computed wrt Original
- Partial distance FIC for original image

Figure(5.4) Performance graph for lenna image of size 256x256 corrupted by film-grain noise with $\sigma^2 = 2$ (Partial distance based FIC)
Figure(5.5) Performance graph for lenna image of size 256x256 corrupted by film-grain noise with $\sigma^2 = 4$ (Partial distance based FIC)

Figure(5.6) Performance graph for lenna image of size 256x256 corrupted by film-grain noise with $\sigma^2 = 16$ (Partial distance based FIC)
Figure (5.7) Performance graph for lenna image of size 256x256 corrupted by film-grain noise with $\sigma^2 = 2$ (Lfd based FIC).

Figure (5.8) Performance graph for lenna image of size 256x256 corrupted by film-grain noise with $\sigma^2 = 4$ (Lfd based FIC).
Figure (5.9) Performance graph for lenna image of size 256x256 corrupted by film-grain noise with \( \sigma^2 = 16 \) (Lfd based FIC)
(a) lenna image of size 256x256 corrupted by film-grain noise with $\sigma^2 = 16$

(b) Compr.Ratio = 4.086  PSNR= 23.981 dB (computed wrt noisy image)

Figure (5.10) Lenna image corrupted by film-grain noise compressed using Fisher's quadtree method
Compr. Ratio = 4.086  PSNR = 23.981 dB (computed wrt noisy image)

Figure (5.11) Lenna image corrupted by film-grain noise compressed using
Partial Distance FIC method

Compr. Ratio = 4.086  PSNR = 23.981 dB (computed wrt noisy image)

Figure (5.12) Lenna image corrupted by film-grain noise compressed using
LFD Based FIC method