CHAPTER 6

ANALYSIS OF FRACTAL IMAGE COMPRESSION ON DIFFERENT IMAGING MODALITIES

6.1 INTRODUCTION

Different types of imaging modalities, their importance in diagnosing, and characteristics of each modality have been discussed in Chapter 5. With the advances in medical imaging and technology, the need for the mass storage and fast communication links is increasing. Since the human eye can process large amounts of information (around 8 million bits), many pixels are required to store images. Storing images in less memory leads to a direct reduction in storage cost and faster data transmissions. This is achieved by compressing the images. The compression methods are categorised as lossy and lossless as given in Chapter 3. Fractal image compression method is one of the lossy compression methods and compression using this method is achieved by either Iterated Function Systems or by Partitioned Iterated Function Systems as given in Chapter 4. FIC using quad-tree encoding of PIFS is applied on the images of different modalities like Ultrasound, CT Scan, Angiogram, X-ray and Mammogram. The performance of FIC on these images is studied based on the compression ratios and the image quality factor PSNR.

6.2 METHOD

Fractal encoding is a mathematical process used to encode any given image as a set of mathematical data that describes the fractal properties
of the image. Fractal encoding relies on the fact that all objects contain information in the form of similar, repeating patterns called an attractor.

Fractal encoding is largely used to convert the image into fractal codes. In the decoding it is just the reverse, in which a set of fractal codes are converted to image. The encoding process has intense computation, since large numbers of iterations are required to find the fractal patterns in an image. The decoding process is much simpler as it interprets the fractal codes into the image.

Normally, the natural images are not self similar. They do not contain affine transformation of itself. By partitioning the images into blocks, partitioned self-similarity can be achieved. The most popular partitioning mechanism is done by partitioning the image in a tree structure. A quad-tree partitioning is a representation of an image as a tree in which each node corresponding to a square portion of the image contains four sub-nodes corresponding to the four quadrants of the square, the root of the tree being the initial image.

The quadtree partition encoding is chosen for this work because it was found to provide the best rate distortion in comparison of polygonal, HV and quadtree partitioning (Reusens 1994a, b). A disadvantage of partitions which are not right angled is the interpolation required in performing the block transforms there is no pixel-to-pixel correspondence between domain and single block (Wolberg and De Jager 1999).

6.3 METHODOLOGY

Fractal Image compression using quad-tree partitioning is applied on gray scale images of different modalities like Ultrasound, CT Scan,
Angiogram, X-ray and Mammogram. Twenty images of size 256×256 of 8 bit gray scale images of each modality are considered for the analysis.

6.4 ENCODING ALGORITHM

- Tolerance factor $T$, minimum recursive tree depth of partition $m$, maximum recursive tree depth of binary partition $M$, bits used for scaling factor and offset factor are considered as 8, 4, 6, 5 and 7 respectively.
- Image is partitioned into four subnodes and is compared with domains from the domain pool $D$.
- The pixels in the domain are averaged, to groups of four so that the domain is reduced to range size.
- The RMSE between the transformed domain pixel values and the range pixel values is found out as,
  \[ e_{rms} = \sqrt{\frac{\min E(R,D)}{n}}, \]
  where $n$ is the number of pixels in the range $R$.
- If the $e_{rms} \geq T$ and depth $\leq M$, the image is subdivided into smaller partitions.
- If the $e_{rms} \leq T$, then the partitioning is stopped and the domain is mapped as $w_i$.

The collection of all such maps is given as $W = \bigcup w_i$, where $W$ is the encoded image.
6.5 **DECODING ALGORITHM**

Decoding an image consists of iterating \( W \) from any initial image. Most of the decoding parameters come from the encoding in order to get the best approximation of the images as given in Chapter 4.

- For each range \( R_i \), the domain \( D_i \) that maps is shrunk by two averaging non-overlapping groups of \( 2 \times 2 \) pixels.

- The shrunken domain pixel values are then multiplied by scaling factor \( s_i \) added to offset factor \( o_i \) and placed in the location in the range determined by the orientation information.

- This iteration is done until the fixed point is approximated by maximum number of iterations, that is, until further image does not change the image or the change is below some small threshold value.

6.6 **PSNR**

Peak Signal to Noise (PSNR) estimates of the quality of a reconstructed image compared with the original image (Mitra et al. 1998, 2000, Fisher 1995). Considering \( f(i,j) \) as original image and \( F(i,j) \) as reconstructed image and \( N \) as number of pixels in the image, the mean square error and PSNR values are computed as given in Equations (1.1) and (1.2). Typical PSNR values range between 20 and 40dB for good quality reconstructed image (Netravali and Haskell 1995). PSNR is the most widely used objective image quality measures. The advantage of this measure is ease of computation.
6.7 RESULTS

Figures 6.1-6.5 show the original images, decompressed images of different imaging modalities.

Figure 6.1 Ultrasound Image

(a) Original Image  (b) Decompressed Image

Figure 6.2 CT Scan Image

(a) Original Image  (b) Decompressed Image
Figure 6.3 Angiogram

Figure 6.4 X-Ray Image
Table 6.1 gives the compression ratios and the PSNR values of different modalities obtained by fractal image compression using quad-tree partitioning.

<table>
<thead>
<tr>
<th>Modality of images</th>
<th>Compression Ratio</th>
<th>PSNR in dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammogram</td>
<td>46.29</td>
<td>32.51</td>
</tr>
<tr>
<td>X-Ray</td>
<td>15.43</td>
<td>31.97</td>
</tr>
<tr>
<td>Angiogram</td>
<td>15.41</td>
<td>29.26</td>
</tr>
<tr>
<td>CT Scan</td>
<td>10.22</td>
<td>28.44</td>
</tr>
<tr>
<td>Ultra sound</td>
<td>8.58</td>
<td>29.41</td>
</tr>
</tbody>
</table>

From the above tabulated values obtained using fractal image compression, it is seen that mammogram has highest compression ratio as 46.29 as well as good image quality with PSNR as 32.51dB. The compression
ratio for X-ray images, angiogram, CT Scan images and ultrasound images is computed as 15.43, 5.41, 10.22 and 8.58 with PSNR values 31.97 dB, 29.26 dB, 28.44 dB, 29.41 dB respectively.

6.8 DISCUSSION

In quadtree partitioning of FIC the compression is achieved by finding suitable transformations defined on image blocks. The transformations of smaller range blocks are carried out by applying transformations on suitably chosen larger domain blocks. The number of transformations required to approximate a given image depends on the image complexity. Large number of transformation leads to poor compression ratio (Mitra et al. 1998).

In this chapter, FIC is applied on different imaging modalities, with different pixel complexity. The compression ratio obtained by FIC is 46.29, PSNR is 32.51 dB the highest for mammogram, where there is a smooth pixel variation. The Compression ratio for X-ray is 15.43 with a PSNR as 31.97 dB and the compression ratio for angiogram 15.41 and PSNR is 29.26 dB. The compression ratio achieved for CT Scan is 10.22 and the PSNR is 28.44 dB. The compression ratio obtained for ultrasound images is found to be the lowest as 8.58 with the PSNR as 29.41 dB, since the pixel variation in ultrasound is very high. PSNR values vary very slightly between the modalities as given in Table 6.1. The variation in compression ratio and the PSNR values is due to the pixel variation in each modality. Because of the properties of fractal compression, though there is a variation in compression ratios of various modalities of images, the image quality is not degraded, which is indicated by the PSNR values in the range between 20 and 40 dB.
In this method, compression ratio obtained for angiogram using FIC is 15.41 where as Benoit Catin et al. (1998) achieved a compression of 12.1 using wavelets on angiogram. A study investigated by Suryanarayanan on the effect of JPEG 2000 on mammography indicated that no significant difference in the perception upto 20:1 compression ratio. Other compression combinations exhibited significant degradation (Suryanarayanan et al. 2004), whereas in this work using Fractal image compression on mammogram, it is possible to obtain a compression ratio of 46.29 with diagnostic accuracy given by the quantitative measures. Kotter et al. (2003) compared the Receiver Operating Characteristics (ROC) of chest X-ray images compressed to 32:1 by fractal, JPEG, Wavelet. Based on the ROC, one of the subjective quality measures, it was found that JPEG and Wavelet did not show much significant degradation between compressed and uncompressed images. Fractal image compression algorithm used results in significance loss at the compression rate. The results obtained in this work show that compression ratio obtained for X-ray image is 15.42 and as it is less than 32:1, the perceptual quality of the image is also good. Using JPEG, David Koff and Harry Shulman (2006), achieved a compression of 20:1 for mammogram, 6:1 for angiogram, 9:1 for CT Scan, 6:1 for ultrasound whereas in this work FIC provides higher values of compression ratio for different imaging modalities.

In this chapter FIC is applied on different imaging modalities and the performance is analysed. In the next chapter, tolerance factor, a parameter that determines the compression in FIC is varied and the effect on the performance of FIC is studied based on the compression factor and PSNR.