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Compressing Land Images using Fractal Lossy Compression

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Abstract: This paper presents a multistep approach for segmenting and compressing satellite based land images acquired from Google Maps in accordance to reduce the storage space and transmission time requirements. Land images are often noisy thus first step involves removing noise by using Adaptive Filter for better enhancement of the image. Then Region Based Segmentation is performed to achieve the uniform regions of an image that helps in mapping areas. Finally compression is performed. This work proposed Fractal Lossy Compression algorithm for compressing Land images as it has tendency to produce efficient and optimal results in different applications. The performance of proposed algorithm is compared with other lossy compression technique i.e Cartesian Perceptual Compression based on some parameters. Experimental results proved that the proposed technique is more efficient, effective and accurate as compared to Cartesian Perceptual Compression.

Keywords: Image compression, Fractal Lossy compression, Region Based Segmentation, Cartesian Perceptual Compression.

1. Introduction

There has been growing interest in recording or storing the information of vast areas of land in the form of images or videos for variety of applications such as mapping terrains, survey programs or monitoring environmental conditions etc. Land data recording is done through remote sensing with the help of satellites or aircrafts. With the increasing demand of storing and sending land images results in lack of sufficient memory spaces and transmission bandwidth. Thus, there is a need of compression algorithm for efficiently utilizing the storage space and network bandwidth resources. There exist many compression schemes categorized into Lossy and Lossless depending upon the fact of losing some information from reconstructed image or not. Lossy schemes are preferable to those applications that can tolerate some loss and requires higher compression ratios whereas lossless schemes are used for applications that cannot afford a minor loss of information. Over the past few years, lossy compression schemes are under researcher's interest because of achieving higher compression ratios [13].

In land data recording, images are used for applications like survey, mapping an area for construction purposes if after compression some information is lost in reconstructed image it will not affect the application results as for these applications there is no need to store each and every minute detail of an image. Thus Lossy compression techniques are better in this case as they can achieve more compressed version of images thus need of storage space and transmission time is reduced.

Fractal lossy compression is proposed for compressing land data images. This technique was initially proposed by Michael F. Barnsley in 1988 and Arnaud E. Jacquin improved fractal compression in 1992 [24]. Traditional image coding techniques encode images by pixel based methods but fractal compression is based on image structure [24]. Fractal compression is best in case of images in which parts of an image often resemble other parts of the same image. Fractal algorithm converts these parts into mathematical data called fractal codes that are used to reconstruct the compressed image. Fractal image compression has many applications in fields [24] such as image encryption, image retrieval [14], image denoising [7] and facial recognition. The method is best suited for photographs of natural scenes (trees, mountains, ferns, clouds). Number of authors has presented the effectiveness of Fractal coding in field of Image Compression.

Fractal image compression is based on affine transformations. R is a function that consists of a linear transformation and translation component. An affine transformation is of the form:

$$Z(x,y)= (ax+b,cx+d) \qquad \text{-(i)}$$

Where the parameters a, c are linear part of transformation and b, d denotes the translation distance in x and y directions.

Let we have a finite collection of contractive affine maps $Z_1, Z_2, ..., Z_n$ that forms an Iterated functions system(IFS). If B is a nonempty subset of R, then the map

$$Z(B) = \cup Z_i(B) \qquad \text{-(ii)}$$

is a contractive map on H, the (complete) metric space of compact sets in R. If Z has a unique fixed point A in H. Then A is said to be compact subset of R and also termed as the attractor of Z.

The rest of this paper is structured as follows. Section II describes the steps of proposed methodology. Further Section III explains the results and discussions based on experiments performed. Finally, the conclusions and future scope is discussed in Section IV.

2. Proposed Methodology

The following are the proposed steps for efficiently recording of land images.

1. Samples images are acquired from Google Maps.
2. Pre-processing of sample images by using Adaptive filter for better enhancement of images.
3. Applying Region Based Segmentation to find the uniform regions of an image.
4. Data Size Reduction using Fractal Lossy Compression.
5. Comparing the results of Proposed Compression algorithm with Cartesian Perceptual compression based on performance parameters.

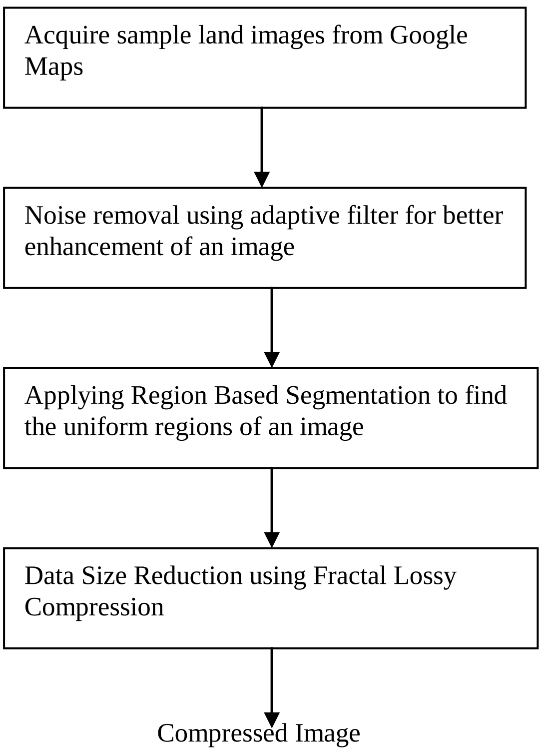


Figure 1: Proposed Methodology

A. Acquire an input image and Preprocessing

Initially Sample land images are collected from Google Maps. First step is to resize the images to 400*180 for making the further processing easier. Land images are often deterioted due to the presence of noise. Next step is to preprocess the sample images by using Noise Removal filter. Thus Noise is removed by using adaptive filter.

B. Applying Region Based Segmentation

Segmentation of the land image based on Region of Interest is performed. Partitioning of the image is performed to extract the uniform patterns in the image to decide to which terrain they belong using Region Based Segmentation based on Threshold value. Input Land image is partitioned into 3 uniform segments that are Urban Area including houses and buildings, Roads and Forests based on gray level values of the pixels in an image. These segments help in mapping an area.

C. Fractal Lossy Compression

Fractal image compression is a compression technique that depends on similarities of an image structure. It is mentioned in literature that small amount of noise is suppressed from an image if noisy image is simply fractally coded [7].

Algorithm of Fractal coding:

1. Divide the image into N non-overlapping parent blocks (PB)-{1,2,…N}.
2. Then divide each parent block into 4 child blocks (CB).
3. Compare each PB with its child block to find the closest match.
4. When PB is found similar to any child block then apply affine transformation.
5. Then store the location of parent block, transform component and related child block.
6. Repeat above written steps for each parent block to achieve compression.
7. Apply the stored information to blank image of the same size as original image to get reconstructed image.

D. Comparison of results/performance with some other compression technique

The results of Fractal Compression algorithm are compared with Cartesian Perceptual Compression technique based on parameters such as Mean Square Error, Root Mean Square Error, Peak Signal to Noise Ratio and CPU Processing Time. These parameters are described briefly:

1. *Mean Square Error* (MSE): It is the difference between the compressed image and original image. It checks the error occurred in the image after applying compression.

$$MSE = \frac{\sum_{M,N}[P(m,n) - Q(m,n)]^2}{M * N} \qquad \text{- (iii)}$$

where M and N denotes the number of rows and columns in the images and P and Q are original image and reconstructed image after compression respectively.

2. *Root Mean Square Error* (RMSE) is smaller, the performance is better. It is computed by using following equation:

$$RMSE = \sqrt{MSE} \qquad \text{- (iv)}$$

3. *Peak Signal to Noise Ratio* (PSNR): This parameter measures the peak error between the compressed image and original image. Thus, for better results the value of this parameter must be high which denotes the better image quality. The PSNR is computed from following equation:

$$PSNR = 10 \log_{10}\left(\frac{MAXi^2}{MSE}\right) \qquad \text{- (v)}$$

where MAXi is the maximum possible pixel value of an image and this value is taken as 255.

4. *CPU Processing Time*: It calculates the time taken by an algorithm to compress and reconstruct the image. Hence, for better results this parameter value must be small. It checks the efficiency of algorithm that how fast that can complete its task.

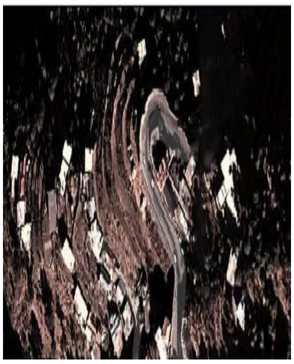
5. *Image Size*: It calculates the size of an image before and after compression. This parameter value depends on the compression ratio, higher the compression ratio smaller will be image size.

3. Results and Discussions

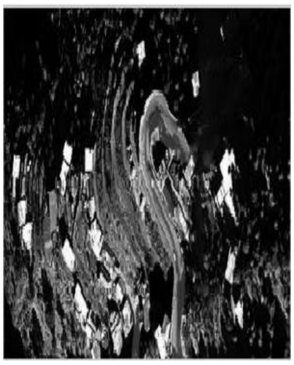
This section presents the results obtained on land images. The screenshots and tabular results are presented in this section. For better understanding, the comparison results are also presented in Graphical form. The Proposed work is implemented in Matlab.

A. Screenshot Results

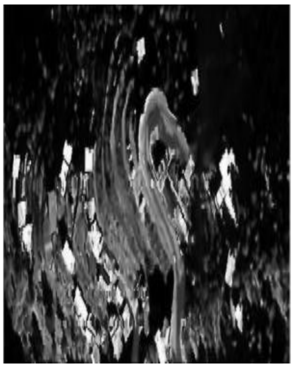
In below figure , (a) presents the original land image taken from Google Maps, (b) presents the image after converting to Grayscale, (c) presents the denoised image after applying adaptive filter, (d) presents the urban area of an image by white color ,(e) shows the roads of an image with white color and black color shows the area of rest of the image,(f) shows the forests with white color and black color denotes the rest of the regions of an image.



(a) Original Image



(b) Grayscale Image

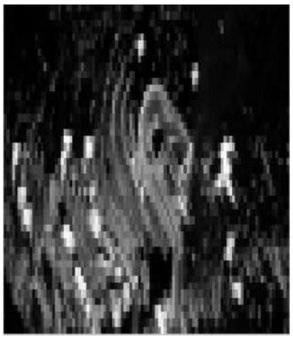


(c) Denoised Image

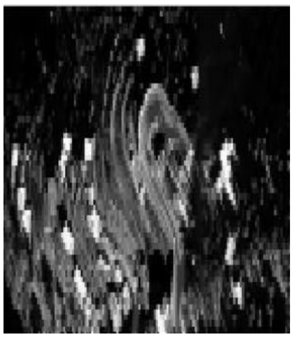
(d) Urban Area

(e) Roads

(f) Forests



(g) Fractal Compression



(h) CPC

Figure 2: Screenshot results on sample land image.

B. Comparison Table

Table 1: Comparison Results of Proposed Fractal Compression with Cartesian Perceptual Compression

Parameters	***Fractal Compression***	***Cartesian Perceptual Compression***
CR	16	9.1755
MSE	0.86057	0.89844
RMSE	0.92767	0.94786
PSNR	48.7829	48.5959
Image Size	4.3945	7.6631
CPU Time (in milliseconds)	131.26	230.13

C. Comparison Graphs

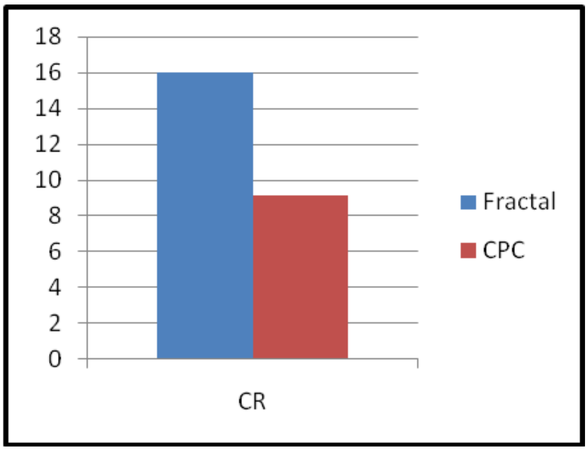


Figure 3: Comparison of Proposed Fractal Compression with CPC (Parameter CR)

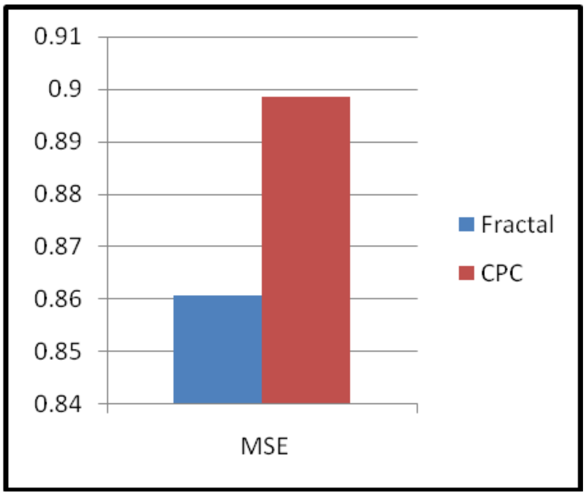


Figure 4: Comparison of Proposed Fractal Compression with CPC (Parameter MSE)

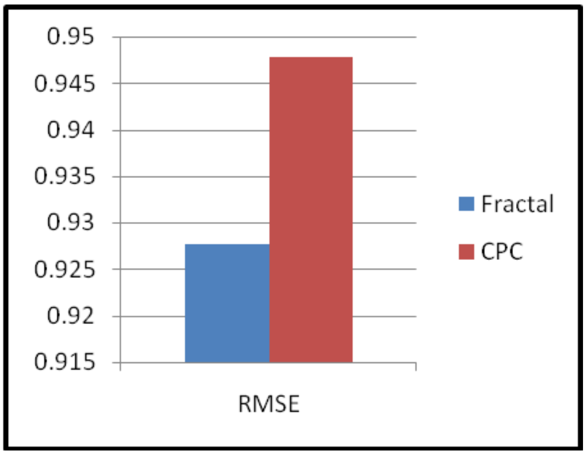


Figure 5: Comparison of Proposed Fractal Compression with CPC (Parameter RMSE)

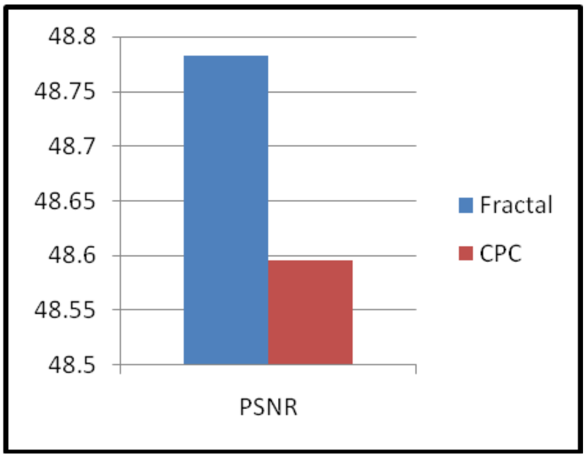


Figure 6: Comparison of Proposed Fractal Compression with CPC (Parameter PSNR)

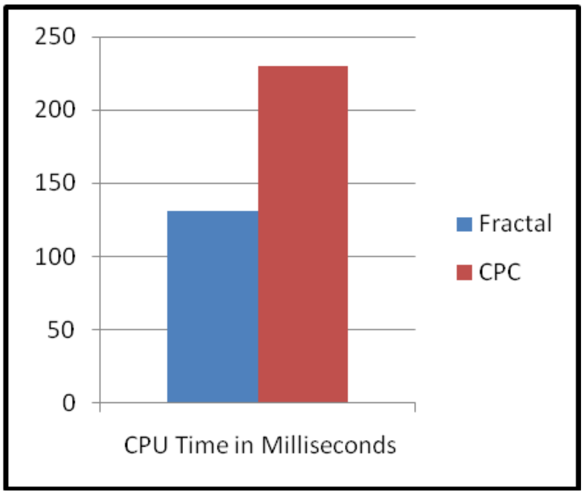


Figure 7: Comparison of Proposed Fractal Compression with CPC (Parameter CPU Time)

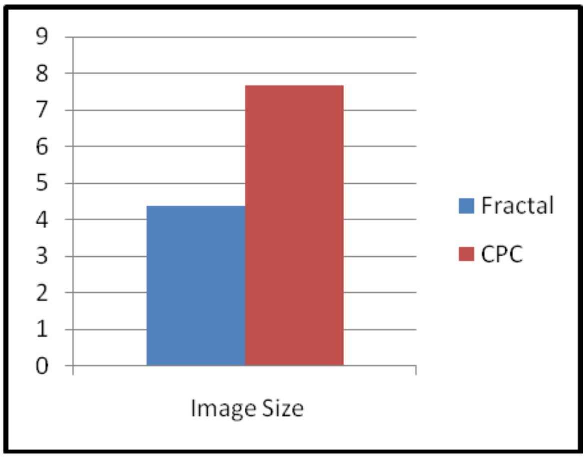


Figure 8: Comparison of Proposed Fractal Compression with CPC (Parameter Image Size)

4. Conclusions and Future Scope

A.Conclusions

Image compression finds its important role in telecommunication applications such as video conferences etc. Land images take a huge amount of memory thus image compression is required to minimize the storage requirements.The increasing interest in image compression has led to the development of many new compression techniques.

Experiments are carried out to compress the different Land images with both algorithms and the results show the proposed algorithm is faster and leads to improve the rate distortion performance as compare to existing algorithm.

As the proposed technique falls in lossy compression category, it can be useful for compressing land images where small amount of information loss can be tolerable.

B. Future Scope

Presently human interaction is required to run the code but in future full automation can be possible. This work compress images of land but in future my work extends to compressing videos of vast land areas.

Experimental results demonstrated that introducing Fractal Image Compression algorithm in other applications has great future in improving the compression performance. Still, huge amount of research is going on Image Compression Techniques and there is lot of scope to contribute in this domain by new researchers.

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