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A Study of an Efficient Hybrid Image compression Algorithm Using DWT

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ABSTRACT: ***Aim of Image compression is to reduce the data amount for transmission and storage purpose. Fractal and (Set Partitioning in Hierarchical Trees) SPIHT compression are two promising techniques of image compression used in this paper. In the aspect of improving code quality and reducing decoding time, Fractal image compression is used, but it cannot raise coding efficiency. In order to improve the coding efficiency and reducing encoding time SPHIT compression is used, but complexity of encoding process is high. As a compromise of the above two methods, a hybrid compression is proposed and implemented. This compression is given full consideration to Human Vision System.***

Human eye is not perceptive to errors which occur in gray-scale; instead it is perceptive to edge features. In this paper, we present a compression technique for an expert hybrid image. The proposal of this paper includes the improvement of the SPIHT algorithm and Fractal image compression technique. The improvement can be achieved by using the combination of the SPIHT and the fractal coding techniques. The introduction of the filter improves the results more. The algorithm include the both the features of the fractal coding and the SPIHT.

The Experimental results show the comparison between the algorithms and the reconstructed image quality. The PSNR and the coding time are the parameters which we use for the validating the algorithm.

Keywords: HVS, Fractal Coding, SPIHT, DWT, PSNR.

I.Introduction

Image compression can be defined as reduction of amount of data used to represent an image by reducing redundant data, so image can be stored or transferred more efficiently, the aim of image compression is to reduce data amount required for representing sampled digital images and cost reduction for storage and transmission. Image compression which plays a important role in many important applications, including image database and communications, remote sensing, document and medical imaging, facsimile transmission (FAX), and the control of remotely piloted vehicles in military, space, and hazardous waste control applications and similarly which expands number of applications based on efficient manipulation, storage and binary transmission, gray-scale or color images.

Human visual system (HVS) has different sensitivity for different frequencies; it is very less sensitive to gray error in the high average brightness area. The human eyes have higher special resolution to the luminous signal than the chroma signal due to the weighted sum operation with the signal the eyes produce a feeling of the edge image enhancement. The human visual masking effect produces a partial effect because it is subjected to background illumination, texture complexity and the signal frequency. Though it can easily feel the change of the edge position the human eye is not sensitive to the grey error of the edge.

Discrete Wavelet Transform is a technique for transforming image pixels into wavelets, and also used for wavelet-based compression and coding. Discrete wavelet transformation which has the frequency localization properties, hence the image can be decomposed based on the frequency characteristics. The Discrete cosine transform algorithm is the one which has been used wider for image compression methods.

As per Embedded zero tree wavelet transform algorithm [1] the complexity involved is more and compression process is slow, and has a disadvantage of edge blur. So hence SPIHT [2] was proposed to enhance the EZW. SPIHT algorithm uses a special data structure, i.e. special orientation of trees. It takes of the special redundancies between the wavelet coefficients. The three special trees are divided into 2, 2 factor groups. They are LL, HL, LH, and HH. The generalized SPIHT is used as the algorithm to reduce encoding time and the fractal compression is a lossy compression method, it seeks to construct an approximation of the original image which is accurate and acceptable. There are other more traditional methods of compressing images and this work very well so that fractal compression which performs approximation and closer to the original image at higher compression ratios. The Fractal and SPIHT are combined to achieve an efficient Hybrid Image Compression.

Contribution: In this paper Hybrid Algorithm is proposed to improve code quality and reducing decoding time by using SPHIT and Fractal image compression.

Organization: This paper is organized into following sections; section II is an overview of related work, Section III is discussed about compression definition and proposed model, section IV is about algorithm used for compression section V is about performance analysis and section VI is about conclusion of the paper.

II .RELATED WORK

Shapiro JM [1] presented a new technique for image coding which produces a fully embedded bit stream. The performance of this algorithm is competitive with all known techniques

Amir Said and W A. Pearlman [2] proved that the set partitioning in Hierarchical trees has better performance than the original EZW or extension of EZW. Here partial ordering by magnitude with the set Partitioning sorting algorithm along with ordered bit plane transmission of the image is being analyzed across different scale of a image wavelet transform. The realization of these principles in matched coding and decoding algorithms is unique and is more effective than the previous implementations of EZW which use more complex algorithms and does not have precise rate control and proper embedded coding. The coding method

An efficient hybrid image compression method is presented by Chunlei and Shuxin Yin[3], this is based on human eye sensitivity. They have proposed a hybrid algorithm based on SPIHT and Fractal image compression. This algorithm improves the coding efficiency, produces good quality of reconstructed image and reduces image encoding time.

Jacquin A [4] proposed a noble approach to image coding which is based on Fractal theory of iterated transformations. It relies on the assumption that image redundancy can be efficiently exploited through self transformability on a block wise basis and approximates an original image by a fractal image.

J.acquin, A.E [5] describes an image coding based on fractal theory of iterated contractive transformation defined piece wise. Image redundancy can be efficiently captured and exploited through piece wise self transformability on a block wise basis by approximating an original image by a fractal image obtained from a finite number of iterations of an image transformation called a fractal code through this approach is not explicitly transmitted but the execution path of any algorithm is defined by the results of the comparison on its branching point.

Joan Puate, and Fred Jordan [6] proposed a signing algorithm that consists of a coding decoding process and retrieving the signature will be performed as a fractal coder. A fractal code for an image is constructed in such a way that it includes a signature; this signature is undetectable without the appropriate key. The main idea of a fractal based image coder is to determine a set of contractive transformations to approximate each block or a segment of the image with a larger block. The main idea to automate the searching of a local IFS relies on the partition of the image in blocks of a fixed size called range blocks, These blocks are then approximated from larger blocks called domain blocks. The transformations normally applied on the domain blocks are contracting, luminance scaling and shifting.

Yozo Iano et al., [7] proposed a paper that presents a fast and efficient image coder in which fast wavelet transform is applied to the quality of fractal compression. Fast fractal encoding is applied to the low pass sub band of wavelet transformed image and a modified SPIHT on remaining coefficients. Compared to pure fractal technique (QPIFS) and pure SPIHT wavelet coding this hybrid method provides an improved quality of pictures for high-medium-low bitrates by avoiding blocking effect. The coding time of Hybrid method is 94% less compared to QPIFS and lies between SPIHT and QPIFS.

Yongseok Jin and Hyuk-Jae Lee[8] proposed an algorithm to improve the processing speed of SPIHT compression algorithm for wavelet transformed images called as block-based pass-parallel SPIHT(BPS).In BPS algorithm the three passes of original SPIHT are reorganized and encoded-decoded in parallel. BPS algorithm increases the speed of both encoder and decoder by modifying the processing order of the original SPIHT that leading to small degradation in the compression efficiency. Compared to the original SPIHT algorithm the loss in the signal to noise ratio using BPS lies between 0.23 and 0.59dB.

Geoffrey M. Davis [9] proposed a paper to introduce a new wave-based framework for analyzing block-based fractal compression scheme.

III. PROPOSED MODEL

In this section definitions of evaluation parameters and proposed model are discussed.

A. Definitions

(i) Mean Square Error(MSE)

The MSE is the cumulative squared error between the compressed and the original image, This can be calculated using equation (1)

$$MSE = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}[I(x,y) - I'(x,y)]^2 \qquad (1)$$

Where I(x, y) is the original image, I'(x, y) is the decompressed image and M, N are the image dimensions

(ii) PSNR

PSNR is a measure of the peak error. Peak signal-to-noise ratio (PSNR), is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation, Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale given in an equation (2)

$$PSNR = 20 * \log10 (255 / \mathrm{sqrt}(MSE)) \qquad (2)$$

B. Proposed Hybrid Model

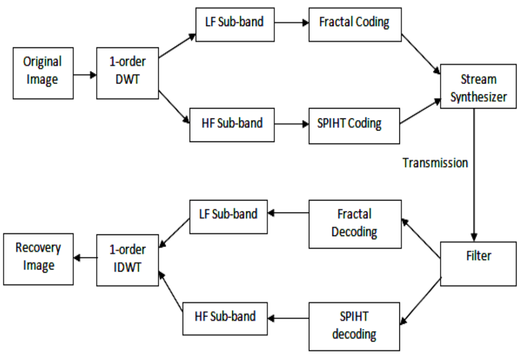
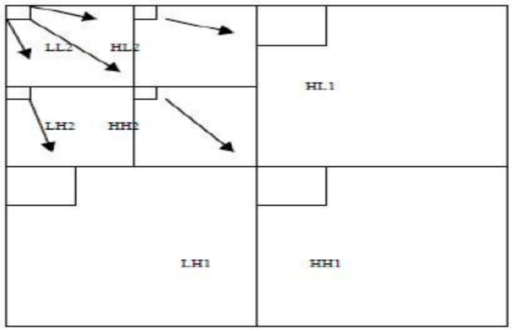


Figure (1) Hybrid coding/encoding diagram

A Hybrid algorithm is achieved by combining the algorithms of fractal coding algorithm and SPIHT algorithm. Specific implementation methods are encoding and decoding. Firstly encoding process is carried out, in encoding process the original image uses first order wavelet transform and multi resolution analysis. By using this analysis the original image is decomposed in to the low frequency (LF) and high frequency (HF) bands. Then LF band uses fractal coding which produces reduce decoding time but cannot raise coding efficiency and HF band uses SPIHT which makes complexity of encoding process. After decomposing the image into low frequency and high frequency sub band, low frequency sub band coding is done which makes the low frequency sensitivity of the human visual signal lossless, high frequency sub band coding reduces the encoding time. These two are synthesized by compressed image after that decoding process takes place. In decoding, Filters are used to avoid aliasing effects; these aliasing filters distinguish high and low streams. Low frequency sub band stream is obtained through fractal decoding and High frequency sub band stream is obtained through SPIHT decoding. Then these two are merged using discrete wavelet inverse transform to get back the recovered image.

SPIHT Compression

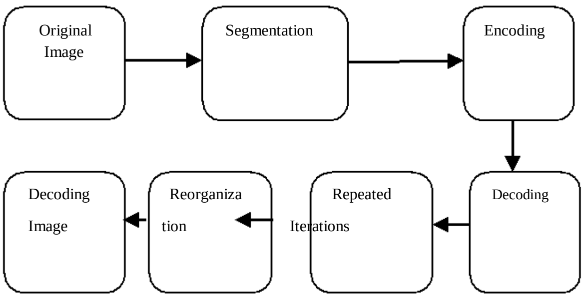


Figure(2) Tree structure used in SPIHT

The coding algorithm based on the Set Partitioning in Hierarchical Trees (SPIHT) is proposed on the foundation of zero-tree coding algorithm EZW, it effectively use the similarity between major coefficients with different scale sub-band, by means of introducing a spatial orientation tree to map the effective value and collect invalid value into a subset as many as possible, then represent with a unit symbol hence, it can save the encoding bit stream in order to achieve data compression. SPIHT algorithm uses a special data structure called spatial orientation trees. This SPIHT structure is not only made the use of different scales and also which correlates the between the wavelet coefficients and also gives full consideration to the correlation of the same scale wavelet coefficients. As shown in Figure (2), in three spatial orientation tree, each layer is divided into four sub-band, the lowest sub-band is divided into four 2 × 2 factor groups, in each of the other three factors has become a root of the spatial orientation tree, that is, in addition to the minimum and maximum sub-bands, at the same location of each factor in its higher level with the direction of the adjacent sub-bands above, there are four direct descendants; the highest sub-band does not have any descendants. In figure (2), arrows indicate that in which way the different scales between these trees are associate to each other. Generally, SPIHT coding involves the coding position of significant wavelet coefficients and the coding of the position of zero trees in the wavelet sub-bands.

In order to improve the coding efficiency and reducing encoding time SPHIT compression is used, but complexity of encoding process is high. So, Fractal image compression technique is used in the next method.

Fractal Compression



Figure(3) Fractal image encoding/decoding diagram

A fractal is a geometric figure, often characterized as self-similar, irregular, fractured, fragmented or loosely connected in appearance. Fractals seem to provide an excellent description of many natural shapes. The fractal theory has been proved to be applicable to many areas, especially in the field of image compression applications. M.F. Barnsley introduces the term of Iterated Function Systems (IFS) based on the self similarity of fractal sets. Since IFS uses the affine transformation, so in solving the IFS parameters, which need to keep looking for similar portions in images. The original meaning of the fractal is the similarity between local and global, that is a portion of the image is the result through affine transformation of a whole image, but as mentioned earlier, the natural image of this local and the whole image self-similarity is rare. More widespread is similarity between the different portions of the image.

The process of fractal image encoding and decoding algorithm process is shown in Figure (3).When fractal coding is progressing first, the original image G is divided into range block Ri with disjoint, 2R× 2R size, each range block can be obtained by "take block" operations. Then search for self-similarity domain block Di in the domain block pool, and the "match" operation can be done, after pass the operation, domain block Di and range block Ri have equal size, then the "reflection-rotation" operation must be take place and compare the gray value of the one after transformed and also the one of domain block. In order to, find corresponding domain block to all the range blocks, make each range block Ri of the image G and can use domain blocks to cover them. Thus, the entire image coding has completed. Compared with fractal encoding, decoding is much simpler.

IV.ALGORITHM

SPIHT(set partitioning in hierarchical trees) algorithm proposed by Amir Said and W.A. Pearlman(2) is a significant improvement of EZW algorithm, it is a amelioration based on the zero-tree structure of the EZW algorithm, SPIHT algorithm uses the smallest mean-square error criterion, the important Wavelet coefficients are first encoded, and it has got a good compression performance because SPIHT algorithm use the same encoding rules for all sub-band, it does not make full use of the characteristics of wavelet coefficients and characteristic of the different sensitivity of the visual image with the different frequency band, it result that the complexity of the encoding process is still very high, the time-consuming is very long and encoding quality is not satisfactory.

In the aspect of improving the code quality and reduce the decoding time, fractal image compression algorithm has enormous natural advantages. Images compressed by fractal image compression algorithm, compression ratio can reach tens of thousands to one and decoding is almost real-time operation, when decoding then it can be arbitrary scale the size and maintain the fine structure of the edge. In this paper, while given full consideration to the characteristics of human vision, which combines the two algorithms, that is fractal algorithm and SPIHT algorithm, to achieve the goal can be hybrid coding.

So, in short the requirement is for a compression methodology with excellent visual quality and good PSNR (after decompression) is required, this also means that all the frequency components of the image is to be maintained and should not be lost in compression. The compression and

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decompression should not take much time to perform as normally the applications are real time. The algorithm of the proposed Hybrid model is shown in below Table 1

Input: Original image
Output: Reconstructed image

1. Divide the original image into LF and HF sub-bands using 1order DWT
2. Then LF sub band is compressed using FRACTAL and HF sub band is compressed with SPHIT compression
3. Then compressed LF and HF data combined together and transmitted
4. Low pass filter is used to avoid aliasing effect in the next method
5. At the receiver LF sub band is compressed using FRACTAL decoding and HF sub band is compressed with SPHIT decoding
6. At Decoding part the LF and HF sub bands are merged
7. By using IDWT the output is obtained
8. Calculate the PSNR value and compare the hybrid image output (reconstructed output) with SPHIT and original image.

The simulation results are shown in the fig(4) and (5) and tables(2),(3),(4),(5). Human eye is not sensitive to gray-scale error but it is sensitive to the image edge features. We use the hybrid algorithm to get the coding efficiency and the image quality.

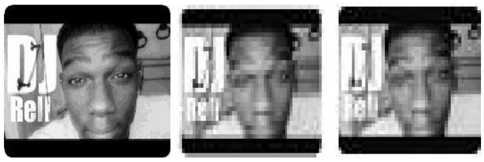
We combine both fractal and the SPIHT algorithm to get the Hybrid algorithm. Image is decomposed into low frequency sub band and high frequency sub band. For low frequency sub-band fractal coding is used. For high frequency sub-band SPIHT compression is used.

As can be seen from tables, at the same bit rate, of the image Lena from table (2) and table (3) the PSNR of the proposed hybrid algorithm for image reconstruction is close to or better than the SPIHT algorithm. At the same bit rate, when using the proposed hybrid algorithm, the coding time of image reconstruction is close to or better than the SPIHT algorithm. Similarly in the table (5) and table (6) of the image artwork the PSNR of the proposed hybrid algorithm for image reconstruction is close to or better than the SPIHT algorithm. At the same bit rate, when using the proposed hybrid algorithm, the coding time of image reconstruction is close to or better than the SPIHT algorithm

(a) (b) (c)

Fig(4) Lena. (a)Original image (b)SPIHT image (c) Hybrid image

B



(d) (e) (f)

Fig(5) Artwork (d) Original image (e)SPHIT image (f) Hybrid

1. COMPARISON OF THE LENA IMAGE WITH DIFFERENT BITRATES.

1) PSNR values for Lena Image.

BIT RATE	SPHIT	HYBRID
0.5	34.6262	34.2206
0.25	33.3349	33.6224
0.125	32.3792	33.3596
0.0625	31.6189	33.2920

Table(2) PSNR/db

2. CODING TIME COMPARISON OF DIFFERENT ALGORITHMS

2) Coding time for Lena.

BIT RATE	SPHIT	HYBRID
0.5	2.859	1.875
0.25	1.547	1.547
0.125	0.844	0.812
0.0625	0.438	0.438

Table (3) Coding/s

3. COMPARISON OF THE ARTWORK IMAGE WITH DIFFERENT BITRATES.

3) **PSNR values for Artwork.**

BIT RATE	**SPHIT**	**HYBRID**
0.5	37.7257	37.3201
0.25	36.5313	36.8187
0.125	35.6493	36.6296
0.0625	34.8672	36.5401

Table (4) PSNR/db

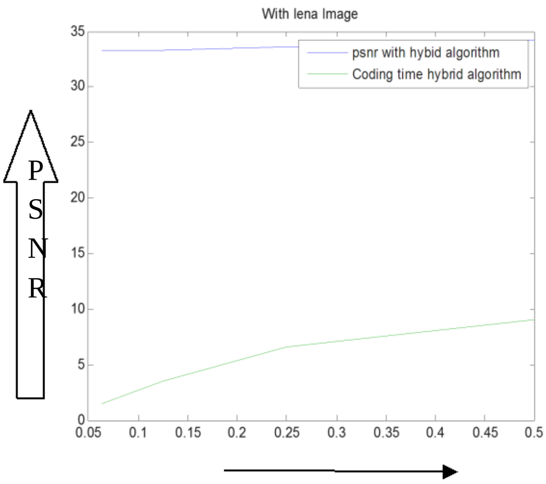
4. CODING TIME COMPARISON OF DIFFERENT ALGORITHMS

4) Coding time for artwork

BIT RATE	SPHIT	HYBRID
0.5	4.0469	4.0625
0.25	2.0938	2.1094
0.125	1.1094	1.0938
0.0625	0.7188	0.6719

Table (5) Coding/s

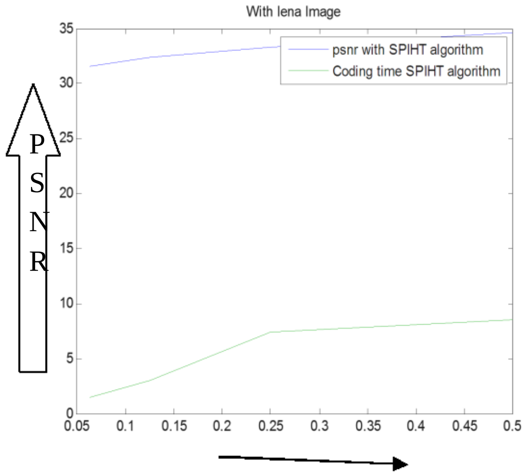
<u>Graphs Generated with Lena and Artwork images</u>



Coding Time

Fig(6)

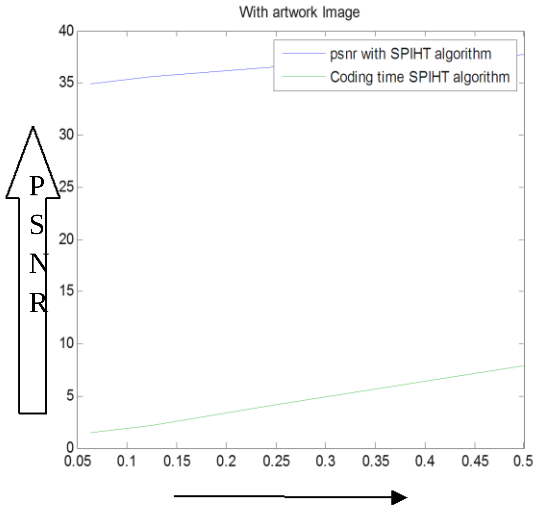
Fig(6) shows the Lena image with a graph psnr and coding time of hybrid algorithm.



Coding time

Fig(7)

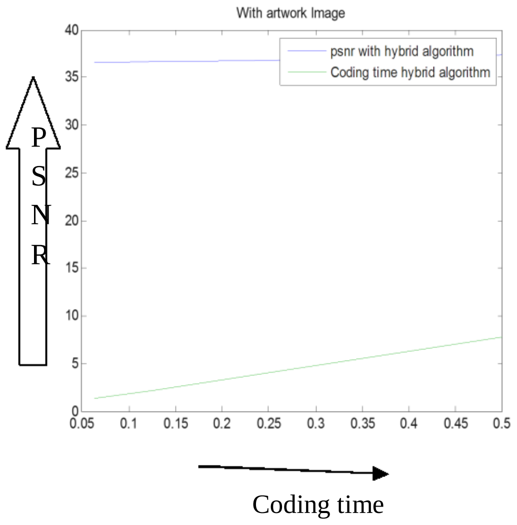
Fig(7) shows the Lena image with a graph psnr and coding time of SPHIT algorithm.



Coding time

Fig(8)

Fig(8) shows the artwork with a graph psnr and coding time of SPHIT algorithm.



Fig(9)

Fig(9) shows the Artwork with a graph psnr and coding time of hybrid algorithm.

VI. CONCLUSION

Image compression has become a popular area of research strengths in computer vision. Based on the Human Visual System Fractal image algorithm could be used, but it requires the image to have more similar areas to be more efficient. The SPIHT algorithm gives a better performance regarding the edges in the image to which the human visual system is more sensitive. So, combination of fractal and SPIHT will get the best compression of image considering human visual system. Hence this paper provides best compression raises the coding efficiency and reconstructed image quality but also reduces the image encoding time and simulated in mat lab.

Experimental results show that the Hybrid Image Compression Algorithm not only raises the coding efficiency and reconstructed image quality but also reduces the image encoding time. Therefore, in the field of image processing algorithm has a very broad application prospects.

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