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Satellite Image Compression using Discrete wavelet Transform

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Abstract: Image compression is one of the main task in saving storage requirements and conserving transmission Bandwidth. In this paper, an Image compression based on wavelet transform is proposed to reduce the bit rate for compressing satellite Images. The variable bit rate is obtained using variable thresholding of wavelet coefficients. Some images from LANSAT 8 are compressed and the image quality metrics bits perpixel, PSNR is verified. The proposed method performs better for low bitrate applications in terms of PSNR.

Keywords: *Compression ratio, Landsat 8, PSNR, wavelet,*

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I. INTRODUCTION

The image compression is most important task to be accomplished on order to save storage capacity, several image compression methods are explored in [13] mostly based on spatial features. G.Kwallace in [1] proposed a JPEG standard which is based on the Discrete Cosine Transform (DCT), the method has the advantage of real transform with the limitation of Blocking artifact at low bit rates. The JPEG was replaced by [2] JPEG 2000 standard which used the wavelet transform, the evolved method has the advantage of better compression ratio with the limitations of ringing effect and low resolution. In [3] sujoy paul [4] proposed a method based on multilevel image thresholding was proposed, in which the PSNR was increased based on the maximizing the shannon Entropy using Differential Evolution[5]. K.Uma in [6] explored the genetic algorithms and particle swarm optimization for image compression methods. Several [8][9] algorithms are explored for satellite image compression. In this work a method based on wavelet transform is proposed for LANDSAT 8 [7] imagery and the performance is verified for low bit rate applications.

II. HEADINGS

Image Compression Based On Wavelet Thresholding Method

In this paper an image compression based on wavelet thresholding method is developed to compress Landsat 8 images for low bit rate applications.

As shown in the Fig 1 the block diagram of wavelet based encoder and decoder for compression of images. The first stage is encoding stage for compressing and second stage is decoding for reconstruction of the image. at the encoding stage the image is performed with Discrete wavelet transform with 'db4' wavelet transform. This transformation gives the decomposition of original image into frequency bands. as shown in Fig 2 The LL coefficients are called approximate coefficients ,where the most of the energy is concentrated and much of the information about the image is available. The LH, HL, HH are called the detail coefficients, and the information content is less significant. The image compression is achieved by truncation of these detail coefficients and the different strategies will give different algorithms [10]. In Literature several approaches evolved for different strategies. The limitations like complexity to be considered for applying algorithms to compress satellite images. Hence only one level of decomposition is considered. After decomposition the data is routed to Thresholding stage and quantization stage, this thresholding is done according to the equation 6 which truncates the less significant coefficients to zero which are nearer to zero. The absolute value of the coefficients should be taken for truncation .This truncation increases the number of zero values in the stream which allow for encoding to get compression. Fig 6 shows the histogram of truncated coefficients for band 5 with a threshold value of 2000,The histogram as shown in the figure is shifted toward right, hence the index of the peaked value in the wavelet bin represents zero..The Threshold value is adapted to get different bitrates. To achieve quantization 256 levels are used . After quantization the data is routed for Encoding, several encoding codes [11] [12]are available for encoding ,Huffman code is one popular among them but the computational complexity to be considered for implementation of satellite image compression.Hence a simple variable length code is used for encoding.

Table 2 shows the codes for variable length coding. The quantization Thresholds (symbols) are arranged according to the probability density. The codes are assigned such that higher probable symbols will be coded with less number of bits. In the course of truncation which will increase the number of zeros, so zeros will have high probability density hence it is coded with the first code (i.e.) 1.The indices of the thresholds are coded using variable length coding.The variable length table codes are such that number of zeros preceded by one will be the index and number of bits followed by 1 will give the unique code of the symbol.

Variable length coding:

For example: 8
Code: 000---1----001

The above code interpretation is such that three zeros before 1, so three bits after the bit one is the unique code of the symbol 8 with total code 0001001.
So this code is simple for decoding and very compatible for bit level processing .Hence it can be easily adapted for satellite images.

Algorithm for Encoding

- Perform the two dimensional wavelet transform one level decomposition of the image
- Fix the Threshold according to the Bit rate
- Truncate the coefficients nearer to zero to zero.
- Perform the quantization
- Find the histogram & probability density of quantized symbols
- Encode the image threshold indices using the variable length coding

Decoding Algorithm

- Decode threshold values from the binary stream with variable length code.
- Apply the two dimensional inverse wavelet transform .

Experimental Results And Analysis

The Landsat 8 images, Band 5 and Band 6 have been selected for verifying the performance of the developed compression algorithms based on wavelet transform. The results are carried out in Matlab 2013a.The experiment results shows that Bit Rate is obtained by varying the thresholds chosen for truncating the coefficients. It is seen from the table 1 the PSNR varies from 42 db to 55 db for bit rate of 2 bpp to 4 bpp. The algorithm for the proposed method is coded in Matlab 2013a, and implemented on a PC with 8GB RAM, 64 bit OS, intel (R) core(TM) i5-4460, CPU@3.20GHz as specifications.

III. INDENTATIONS AND EQUATIONS

$$\text{compression ratio(CR)}=\frac{\text{Compresed Image File size}}{\text{Original Image File size}} \quad (1)$$

$$\text{Bit Rate (bpp)}=\frac{\text{Compresed Image File size}}{\text{Original Image File size}} \text{ x 16. For 16 bit images -} \quad (2)$$

$$\text{Bit Rate(bpp)}=\frac{\text{Compresed Image File size}}{\text{Original Image File size}} \text{ x 8 For 8 bit images -} \quad (3)$$

$$\text{MSE}=\sum_{MN}\left(I(m,n)-C(m,n)\right)^2 \quad (4)$$

$$\text{PSNR}=10\log_{10}(\text{R}^2/\text{MSE}) \quad (5)$$

MSE - Mean Square Error
PSNR - Peak Signal to Noise Ratio
M - Number of Rows
N - Number of Columns
R - 65535 for 16 bit images, 255 for 8 bit images
I - Original image
C - Reconstructed image

The compression ratio indicates the measure of reduction in the original file size and the PSNR indicates the measure of quality of the reconstructed image.

T(x) = 0 for abs(x) <=T
T(x) = x for T(x) > T (6)

IV. FIGURES AND TABLES

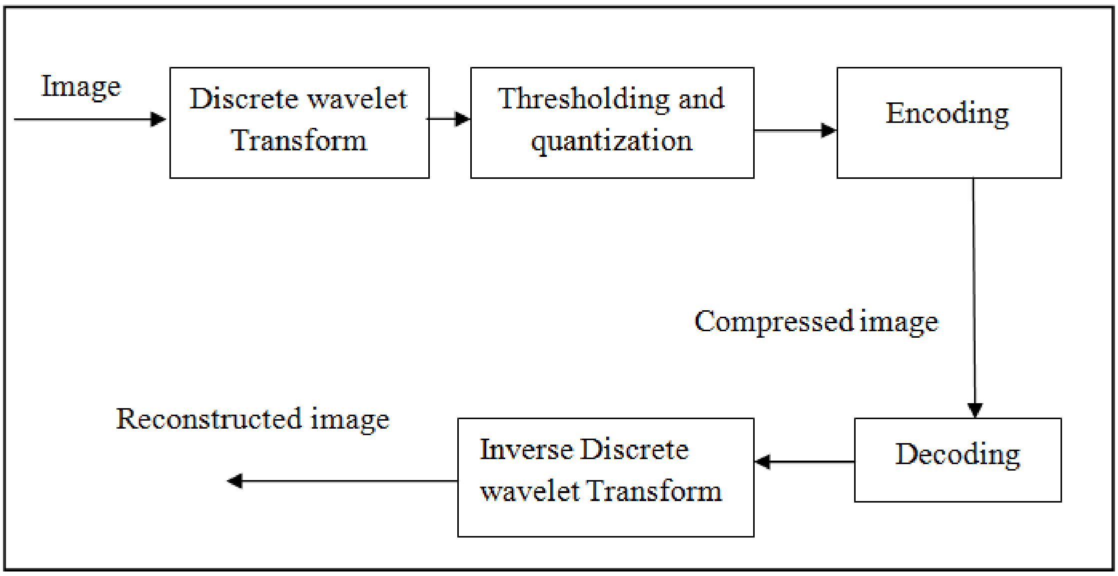

Fig 1 Block Diagram of Wavelet Based Encoder and Decoder

LL	LH
HL	HH

Fig 2 One Level Wavelet Decomposition of Original Signal

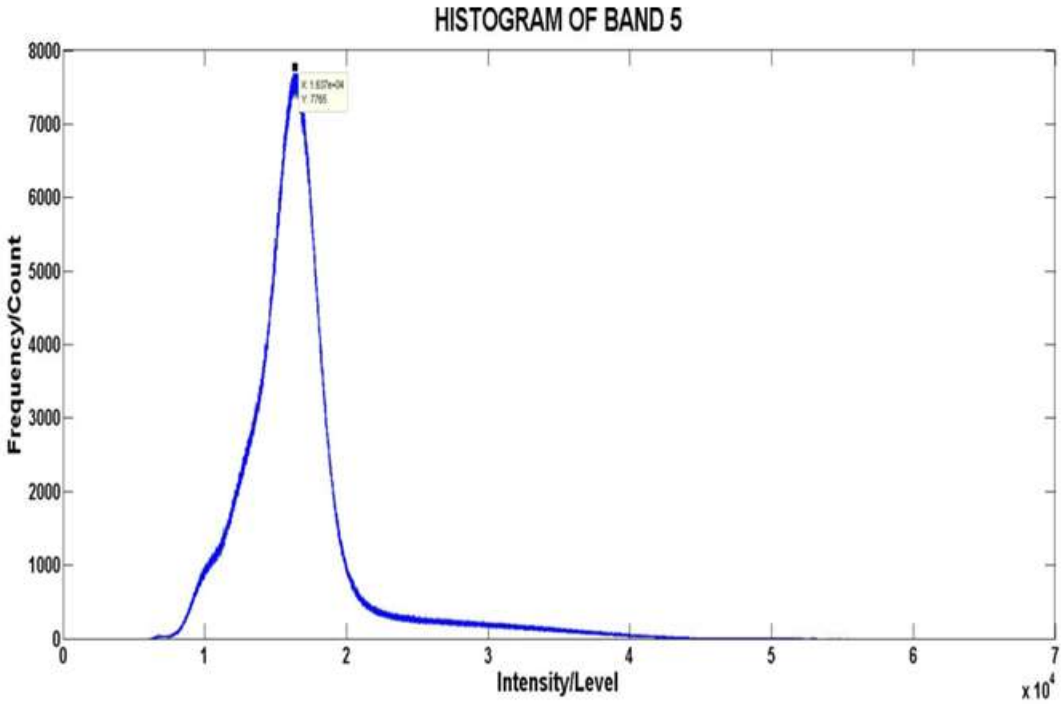

Fig 3 Histogram of Band 5

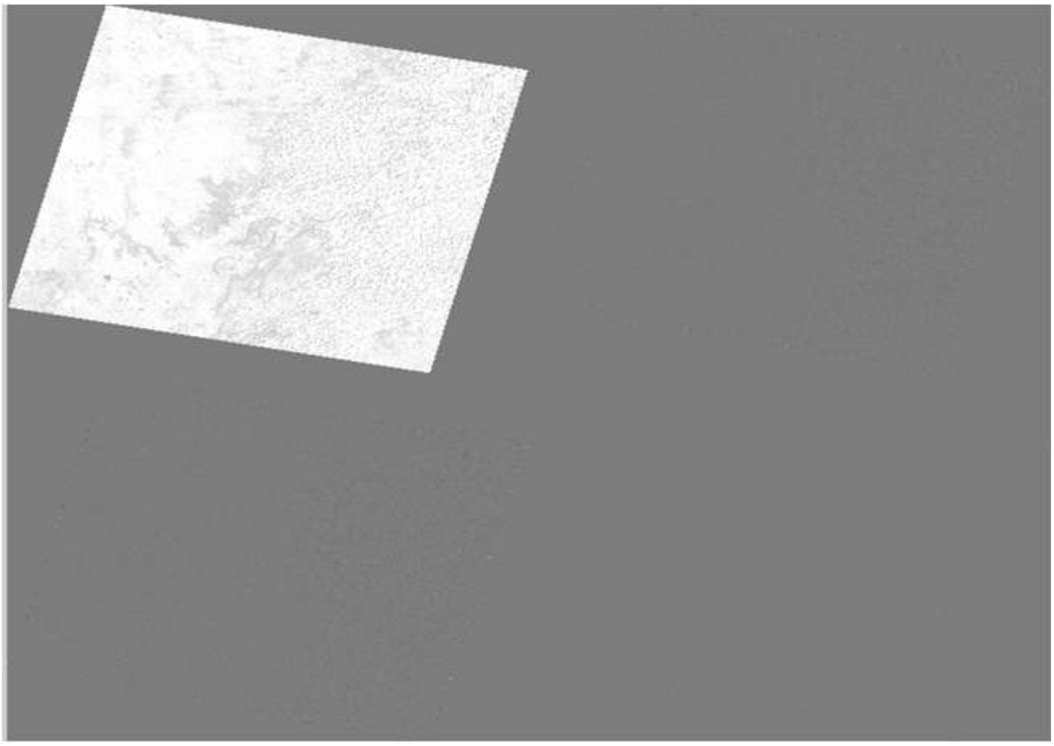

Fig 4 One level decomposition of Band 5

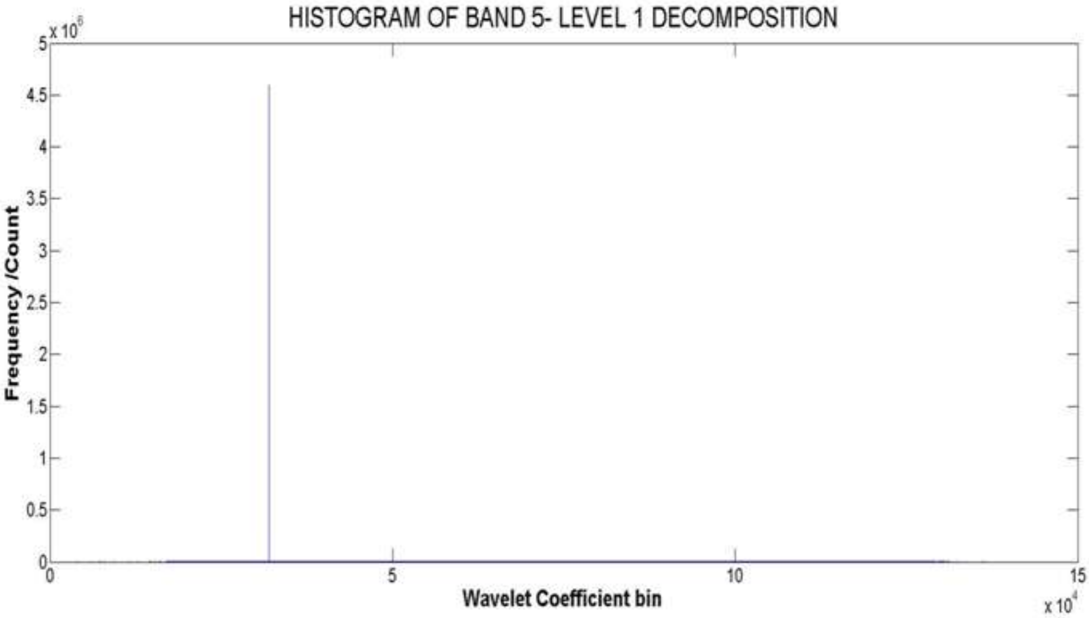

Fig 5 Histogram of wavelet coefficient bin Band-5

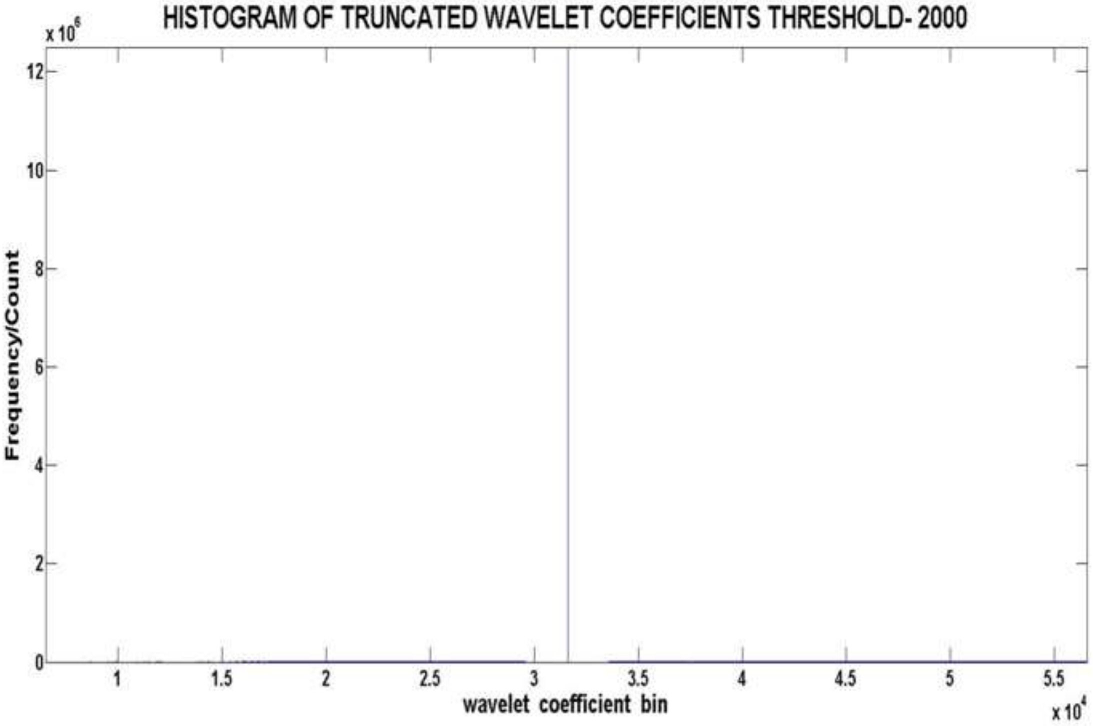

Fig 6 Histogram of Truncated Coefficients for a Threshold Of 2000

Table 1 Band 5 bpp Vs PSNR

bpp Vs PSNR		
Threshold For 256 quantization Levels	**bpp**	**Band 5 PSNR in db**
2000	2.23	44.63
1000	2.53	47.50
500	3	51.6
200	4.08	54.98

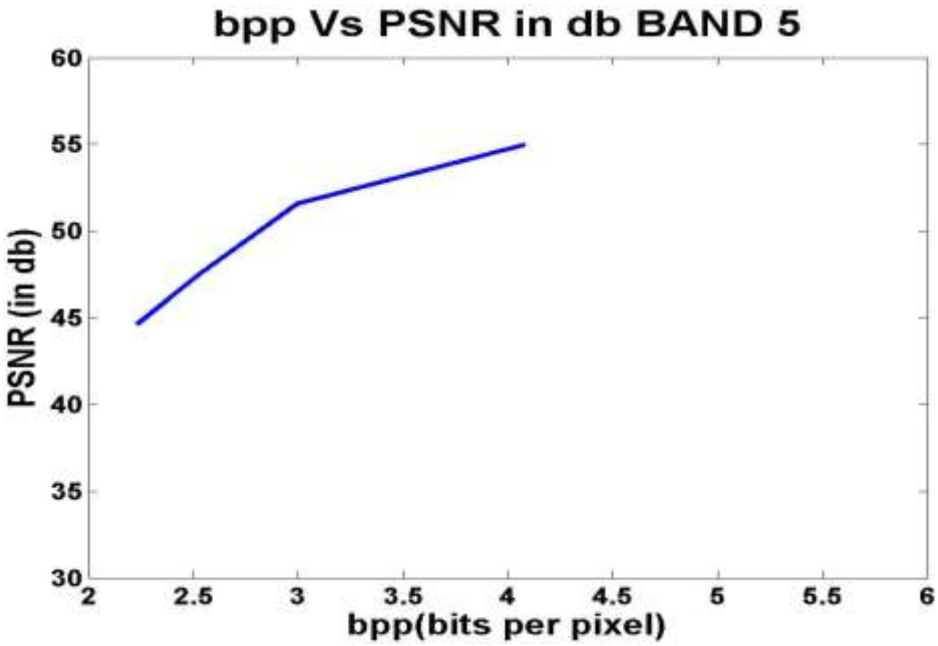

Fig 7 bpp Vs PSNR Band 5

Table 2

Symbol	Code
0	1
1	010
2	011
3	00100
.	.
.	.
.	.
.	.
255	000000011111111

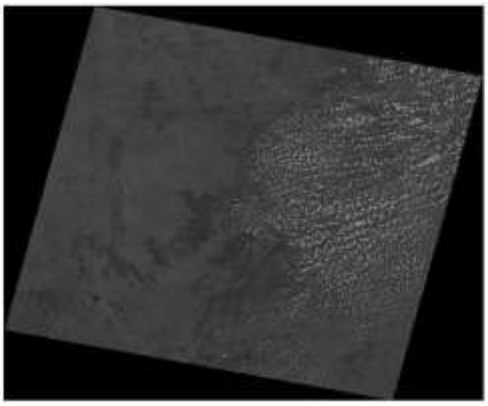

Fig 8 Orginal image Band 5

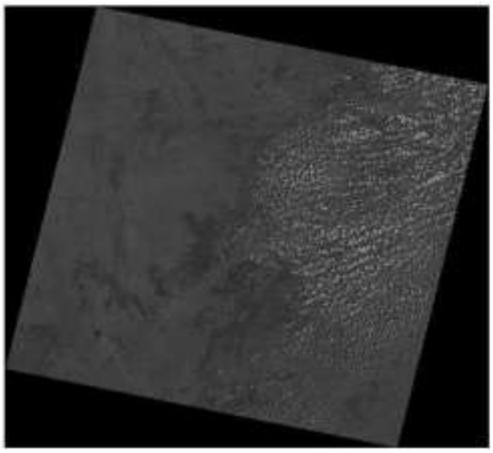

Fig 9 reconstructed image for bpp 2.2

V. CONCLUSION

In This Paper a simple compression algorithm for Compressing satellite Landsat 8 images is developed and the performance is simulated for variable bit rates.For low bit rate applications a better PSNR is obtained using this proposed method.

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