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Image compression Based on Uniform Thresholding and Fixed Point Binary Scaling

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Abstract: Image compression is one of the main task in saving storage requirements and conserving transmission bandwidth. In this paper, a image compression based on uniform thresholding and fixed point binary scaling is proposed to reduce the computational complexity for compressing satellite Images. The variable bit rate is obtained using fixed point binary scaling and adjusting slope factor. Some images from LANDSAT 8 are compressed and the image quality metrics bits per pixel(bpp), peak signal to noise ratio(PSNR) and computational time are used for comparison. The proposed method from medium to high bitrates performs better than the discrete cosine transform(DCT) based method in terms of PSNR and computational time.

Keywords: bpp, PSNR, fixed Point, Computational time.

I. INTRODUCTION

The image compression is most important task to be accomplished in order to save storage capacity, several image compression methods are explored in [1] mostly based on spatial features. G.Kwallace in [2] 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 [3] 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 [4] sujoy paul [5] 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 [6]. K.Uma in [7] explored the genetic algorithms and particle swarm optimization for image compression methods. In our work we propose an image compression algorithm based on thresholding for LANDSAT 8 [8] imagery and the Results are compared with DCT based method.

II. DCT BASED METHOD

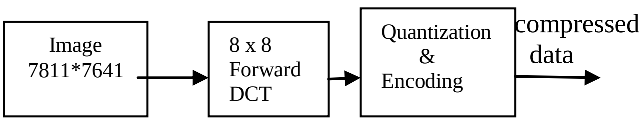

Fig.1. Base line of the DCT based encoder.

The DCT based encoder in Fig.1 performs the forward discrete cosine transform on the 8x8 blocks of input image. Each block is quantized by a factor of 10, and the quantized data is routed to the encoder. The encoder retains the low frequency coefficients of the 8x8 blocks according to the bit rate required. The retained coefficients are encoded with the lowest possible bits per pixel i.e. int16 data type .

Forward DCT:

$$F(u,v)=\frac{1}{4}C(u)C(v)\sum_{x=0}^{7}\sum_{y=0}^{7}f(x,y)\cos\left[\frac{\pi(2x+1)u}{16}\right]\cos\left[\frac{\pi(2y+1)v}{16}\right]$$

for $u=0,\ldots,7$ and $v=0,\ldots,7$

$$\text{where } C(k)=\begin{cases}1/\sqrt{2} & \text{for } k=0\\ 1 & \text{otherwise}\end{cases}$$

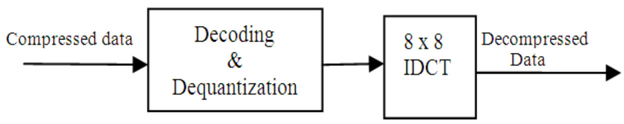

Fig. 2. Base line of the DCT based decoder.

Inverse DCT :

$$f(x,y)=\frac{1}{4}\sum_{u=0}^{7}\sum_{v=0}^{7}C(u)C(v)F(u,v)\cos\left[\frac{\pi(2x+1)u}{16}\right]\cos\left[\frac{\pi(2y+1)v}{16}\right]$$

for $x=0,\ldots,7$ and $y=0,\ldots,7$

The compressed data is decoded and dequantized accordingly done at the encoding stage. The decompressed data is obtained by performing the dequantization and inverse discrete cosine transform (IDCT). The image is reconstructed with the same dimensions and data type of the original image. The performance of the DCT based method can be improved by using Run length codes and Huffman table [3]. This approach increases the memory requirements and computational complexity of the algorithm.

III. PROPOSED METHOD

A. The Thresholding technique basically makes an approximation of the image histogram by properly choosing the set of thresholds, when the image is threshold into n+1 levels only log2(n+1) bits is required to represent the image. The thresholds are obtained by fixed point object creation. Landsat 8 images are having size of

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7811x7641 and uint16 data type with the intensity variation of 0 to 65535. The slope of the quantizer is adjusted to get different bit rates.

Geotiff file information of Band-1.
FileSize: 119430538, Format: 'tif', Height: 7811,Width: 7641
BitDepth: 16,ColorType: 'grayscale',ModelType:'ModelTypeProjected'
PCS: 'WGS 84 / UTM zone 44N',Projection: 'UTM zone 44N'
MapSys: 'UTM_NORTH',Zone: 44,CTProjection: TransverseMercator'
GCS: 'WGS 84',Datum: 'World Geodetic System 1984'
Ellipsoid: 'WGS 84', SemiMajor: 6378137,SemiMinor: 6.3568e+06
PM: 'Greenwich',PMLongToGreenwich: 0,UOMLength: 'metre'
UOMLengthInMeters: 1,UOMAngle: 'degree',UOMAngleInDegrees: 1

B. Proposed Encoding Algorithm

- The zero pixels are separately encoded by finding the indices of non zero rows and columns. The indices are coded using fixed point object with minimum possible bit length.
- Find the range of pixels, minimum-p, maximum-q.
- Fix Slope adjustment factor = (q-p)/2^n-1.

Where n= number of bits per pixel.

- Perform the encoding for non zero pixels using Fixed point slope and Bias scaling.

Fixed Point object creation:
A=fi(v,s,w,slope,bias)
A= fixed point object,
v= value of data to be encoded
s= sign bit, 0-unsigned 1-signed.
w= bit length
slope = slope adjustment factor
bias = minimum value of pixel- p

C. Proposed decoding algorithm.

- Using indices of zero pixels, the cells are filled with zeros
- Non zero encoded data is decoded from conversion of fixed point object to data type uint16.

IV. EXPERIMENTAL RESULTS

The Landsat 8 images, Band 1-blue - 43 μm & Band 10-TIRS1-10.6 μm have been selected for verifying the performance of the proposed method. The results are carried out in Matlab 2013a. The compression metric bits per pixel (bpp) is the total bit budget (bit budget for zero pixels + bit budget for non zero pixels) is calculated as given in equation (1). The PSNR is calculated for different bit rate(bpp) from the defined equation (2). The results obtained for different bitrates and the respective PSNR is given in the table I. It is observed that at low bitrates DCT based method slightly performs better than the proposed method in terms of PSNR. From medium to high bit rates the proposed method out performs the DCT based method, nearly an average gain of 6dB in PSNR is achieved at the cost of increasing 1bpp. It is also seen from Fig.3 that the performance of the proposed algorithm at 10bpp nearly approaches lossless compression. It is seen in the Fig.4 , the proposed method performs slightly better than the DCT based method. 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. The proposed method is tested for computational complexity and the results are compared with DCT method. It is seen from the table II that the encoding time and decoding time is same for the DCT method nearly 269 seconds, where as the proposed method the encoding time is 43 seconds, decoding time is 37 seconds nearly 5 times less than DCT based method. Hence the proposed method out performs DCT method in terms of computational complexity. The original image Band-10 in Fig.5 and reconstructed images of the DCT method and proposed method is shown in Fig.6 and Fig.7 respectively. The limitation of the proposed method is that the compilers should compatible with fixed point object.

bpp=(output file size/input file size) x16. (1)

another metric, Peak Signal to Noise Ratio(PSNR) is measured for the different bitrates.

$$PSNR = 10\log10(R^2/MSE) \quad (2)$$

$$MSE = \frac{\sum_{MN} [I(m,n) - C(m,n)]^2}{(M*N)}$$

Where M=number of rows, N= Number of columns
I= original image, C= reconstructed image R= 65535.

TABLE I

Image Band -1 blue- .43 μm				Image Band -10 TIRS1-10.6 μm			
DCT method		Proposed method		DCT method		Proposed method.	
bpp	PSNR In db	bpp	PSNR In db	bpp	PSNR In db	bpp	PSNR In db
4	48	4.8	41	4	48	4.7	46
6.2	51	6.2	54	6.2	50	6.1	54
9	56	9	78	9	52	7.4	55
12.2	57	10.4	90	12.2	56	10	56

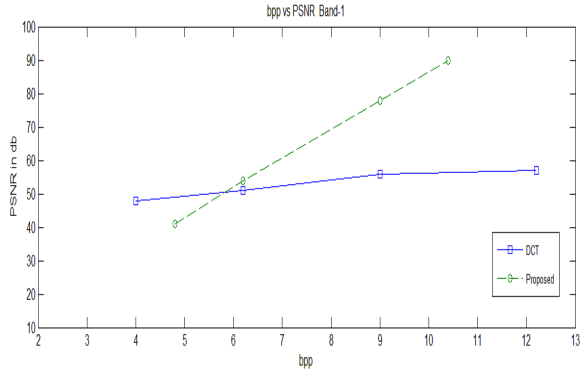

Fig.3: bpp Vs PSNR Band 1

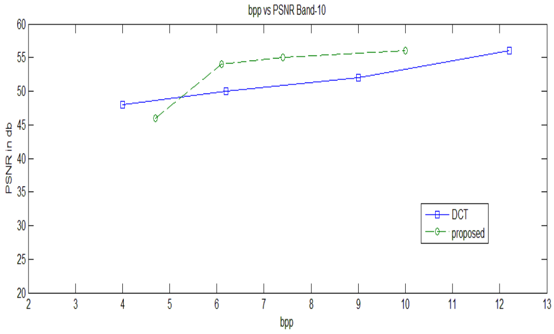

Fig.4: bpp Vs PSNR Band 10

Table II

Average compression Time(S)		Average Decompression Time(S)	
DCT	Proposed	DCT	Proposed
269	43	267	37

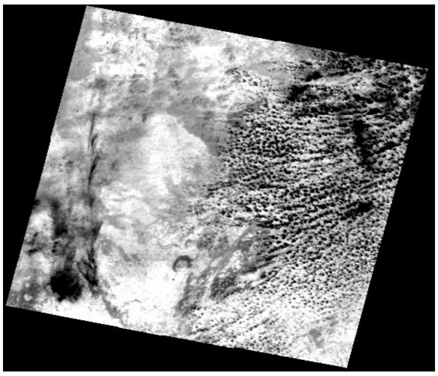

Fig. 5: Original image Band-10-16bpp

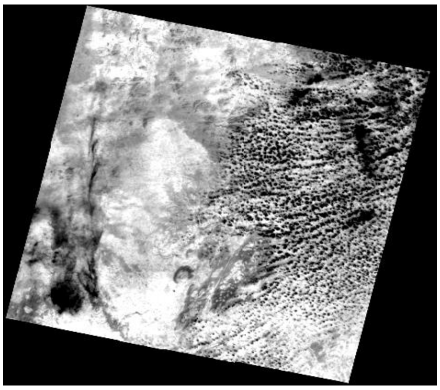

Fig.6: Reconstructed image-DCT -9bpp

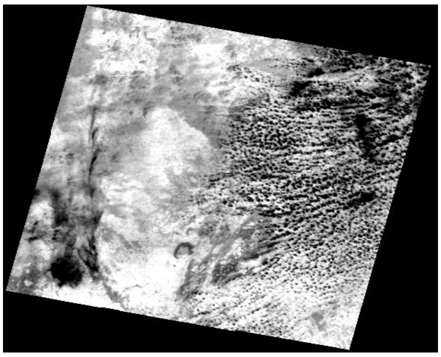

Fig.7: Reconstructed image proposed method-10bpp

V. CONCLUSION

In this paper, an image compression based on uniform thresholding and Fixed point binary scaling is proposed to compress Landsat 8 satellite images. The methodology of the above algorithm is properly explained and the proposed method is significant in terms of computational time. Future work will be concentrated in making use of several entropy based thresholding for increasing PSNR without much increase in computational time.

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