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ROI Compression of Satellite Images Using Modified JPEG Standard

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Abstract:—Satellite image compression is one of active image processing areas. In this paper we proposed a novel approach for ROI compression of multiband satellite images using modified JPEG standard. In this paper, we show how the quantization may be adapted in each block and how we may signal to the decoder in a memory-efficient manner. This allows ROI coding of satellite images. The method takes advantage of unused slots in the Huffman tables. We made the output modification that is in compliant with the standard and also we proposed how the decoder may be modified to correctly recover the ROI quantized satellite images.

I. INTRODUCTION

Satellite images contain clouds, the information about clouds is irrelevant in these images. However in current on-board compression algorithms pixels of clouds are processed as any other pixels of the image and are transmitted with the same quality and bit rate. This results in a waste of data rate which could have been used either to enhance the quality of the relevant part of the transmitted image or to transmit more images. The goal of selective image coding is to avoid this waste by on-board cloud detection and ROI coding techniques. This paper focuses on this second point: the implementation of ROI coding techniques using modified JPEG

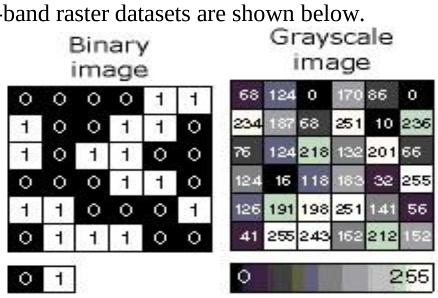
In this paper we demonstrated a method for ROI compression by varying the quantization matrix from block to block, and described the signaling of adaptive quantization to the decoder in a way that is compliant with the JPEG standard. To recover the exact image by Adaptive quantization[1], the decoder should vary the Q matrix exactly as the encoder, over the image. After Adaptive Quantization the encoder must signal to the decoder on each block which Q matrix that it used, also the signalling must be compliant with the JPEG standard[2] if any "standard" decoder is able to process the adaptively-quantized image. Huffman table in JPEG standard has few unused slots for end-of-block(EOB) symbols. Our method has taken advantage of those unused slots for end-of-block (EOB) symbols in the Huffman table. This allow us to signal up to 14 different levels of quantization within a color plane and thus allows us possibility of ROI compression. standard decoder treats all 14 EOB symbols as the same. However, to recover image that is Adaptively Quantized we need to modiy the decoder in a way that it recognizes the EOB symbol and modify the decoding Q matrix appropriately.In this paper we show how previously unused slots in the baseline JPEG Huffman table may be used to signal Q matrix adaptation. This allow us to signal up to 14 different EOB codes to be used on each block. In this paper we described the method to construct the Huffman codes to efficiently encode the adaptively-quantized satellite image.

II. SATELLITE IMAGES(MULTIBAND

Some images have a single band, or layer of data, while others have multiple bands. Basically, a band is represented by a single matrix of cell values, and a image with multiple bands contains multiple spatially coincident matrices of cell values representing the same spatial area. Most satellite imagery has multiple bands, typically containing values within a range or band of the electromagnetic spectrum.
There are three main ways to display single-band raster datasets:

- In a binary image, each cell has a value of 0 or 1 and is often displayed using black and white.
- Grayscale—In a grayscale image, each cell has a value from 0 to another number, such as 255. These are often used for black-and-white aerial photographs.
- Color map—One way to represent colors on an image is with a color map. A set of values is coded to match a defined set of red, green, and blue (RGB) values.

The three main ways to display single-band raster datasets are shown below.



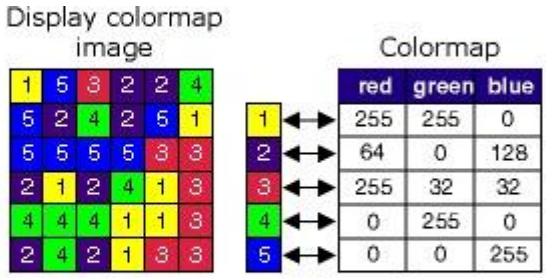


Fig 2 *Binary, Grayscale and Color Image*

When there are multiple bands, every cell location has more than one value associated with it. With multiple bands, each band usually represents a segment of the electromagnetic spectrum collected by a sensor. Bands can represent any portion of the electromagnetic spectrum including ranges not visible to the eye such as the infrared or ultraviolet sections. The term band originated from the reference to the color band on the electromagnetic spectrum.

III. PROCESS

ROI compression for satellite images is as follows.IN JPEG two compression formats available they are Baseline sequential and progressive. The baseline format stores the full resolution of the image in a single sequential scan while progressive format stores several scans of the image. In progressive format each scan has increased resolution over the previous scan. Progressive JPEG is not widely used. In JPEG standard Huffman table is designed to accommodate both progressive and baseline sequential formats. This nature allow us to modify the feature of progressive format to allow signalling of adaptive quantization in baseline sequential format there by making ROI compression of satellite images possible.. The below method describes the ROI compression of satellite images using modified JPEG.

1) The satellite image is converted from RGB to YCbCr, usually followed by sub-sampling of the Cb, Cr planes.
2) Each planes of Y , Cb, Cr are partitioned into blocks of size 8 × 8.
3) The DCT of each 8 × 8 block is calculated. Let x(i, j) denote the (i, j)-the pixel in block, and X(u, v) the (u, v)-th frequency in the DCT and X(1, 1) is the "DC" coefficient, and remaining are "AC" coefficients. The quantization of DCT coefficients using a 8 × 8 matrix Q as follows:

$$X_Q(u, v)=\text{round}\left\{\frac{X(u,v)}{Q(u,v)}\right\} \quad u, v = 1,\ldots,8. \qquad ..(1)$$

Y , Cb, Cr planes may have different Q matrices but they do not vary spatially.
4) The quantized block X_Q is scanned in "zig-zag" order. DC value of the previously coded block is subtracted from the quantized DC coefficient and then it is stored . The scan of AC coefficients is stored in (R, S) format, where R is the number of consecutive zeros followed by the non-negative value S indicating the size of the next non-zero value. If V is the value of the quantized coefficient, then

$$S = \log_2\lfloor|V|\rfloor + 1 \qquad \ldots(2)$$

Here $\lfloor.\rfloor$ is the floor function also two special symbols are also allowed
1).a ZRL symbol represents a run of 16 consecutive zeros.
2).EOB symbol indicates and represent that all subsequent coefficients in the scan are zero.
5) Each scan is Huffman coded, where AC coefficients are organized as a 16×11 structure in the Huffman table. This structure is designed to accommodate 16 different R values and 11 values of S. This structure is shown in table I . The Huffman code for each (R, S) pair in a scan is emitted, followed by S additional bits to indicate the actual value of the coefficient.

TABLE I
HUFFMAN TABLE LAYOUT FOR AC COEFFICIENTS IN BASELINE SEQUENTIAL MODE. ENTRIES MARKED "X" CONTAIN CODES FOR OTHER VALUES.

R \ S	0	1	2	· · ·	9	10
0	EOB	x	x	x	x	x
1	Not used	x	x	x	x	x
⋮	Not used	x	x	x	x	x
14	Not used	x	x	x	x	x
15	ZRL	x	x	x	x	x

From Table I slot for R = 0, S = 0 is used for the EOB symbol, while R = 15, S = 0 indicates 15 consecutive zeros followed by a size 0(ZRL symbol) but the slots for S = 0 and R = 1 to 14 are reserved for the progressive format and are not used in baseline sequential format. We utilized those unused slots for signalling adaptive quantization to decoder thus making it JPEG standard-compliant..

In JPEG standard if S = 0 and R = 15 then 16 consecutive zeros are appended to the zig-zag scan in reconstruction. Otherwise the symbol is treated an EOB. all slots in Table I with S = 0 and R < 15 are considered to be the same EOB symbol. Therefore, additional codes for different conditions may adopted by using the 14 unused slots in Table I.

IV. QUANTIZATION

In the Quantization, The Q matrix is fixed across the color plane. This limits the possibilities of ROI coding. We have overcomed the limitation by signalling to the decoder with proper EOB codes exploiting the unused slots in Huffman table , to say which Q was used. But if we use a standard decoder then it dequantizes an input block with a improper Q matrix. Suppose that the DCT of an 8 × 8 block, X(u, v), $1 \le u, v \le 8$, is quantized at the encoder using matrix Q as in eq.(1). At the decoder, the quantized matrix X Q is used to reconstruct the DCT matrix X using the equation

$$\dot{x}(u,v) = Q(\dot{u},v)XQ(u,v),$$

$u, v = 1,\ldots,8.$ …(3) (3)

$\dot{x}$ will not the same as X due to rounding. If we let P = αQ, where α is a scale factor, then the effect of dequantizing X_Q with P instead of Q is as follows:

$$\tilde{X} = P(u,v)Xq(u,v)$$

$$= \alpha Q(u,v)\text{round}\left\{\frac{X(u,v)}{Q(u,v)}\right\}$$

$$= \alpha X(u,v) + \alpha Eq(u,v) \quad \ldots(4)$$

where Eq = Q round$\{X_Q/Q\} - X$ is the quantization error introduced by rounding.
If we apply P = αQ, we can see that scaling factor is same for every element instead if we choose $P = H \circ Q$, where $\circ$ denotes the elementwise product of H and Q. Here H acts as filtering matrix.

$$\tilde{X}(u,v) = H(u,v)X(u,v) + H(u,v)E_q(u,v) \quad \ldots..(5)$$

we see that dequantization with $H \circ Q$ is equivalent to filtering by H in the DCT domain ignoring the noise term. We may therefore use adaptive quantization as a means to perform spatially adaptive filtering of the image.

V. HUFFMAN TABLE MODIFICATION

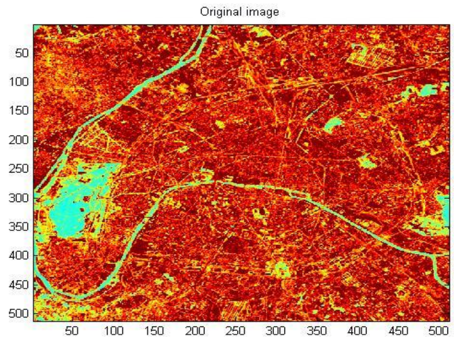
we must modify the entire Huffman codebook to allow for unique decoding[13] . this allow us to use the empty slots in the Huffman table to signal adaptive quantization to the decoder. One method is to substitute a Huffman table for progressive coding in place of the baseline table. This allows us to signal 15 different Q matrices to the decoder. Standard progressive table is shown in Table II. We may or may not use all the empty slots , so we can design Huffman table to support fewer EOB codes.

TABLE II
HUFFMAN TABLE LAYOUT FOR PROGRESSIVE ENCODING

R \ S	0	1	2	· · ·	9	10
0	EOB0	x	x	x	x	x
1	EOB1	x	x	x	x	x
⋮	⋮	x	x	x	x	x
14	EOB14	x	x	x	x	x
15	ZRL	x	x	x	x	x

VI. EXPERIMENTAL RESULTS

We used .lan multiband satellite image files containing 7 bands. MATLAB was used as the programming platform.



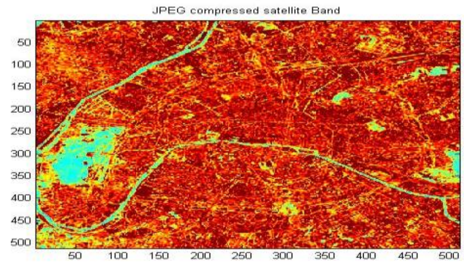


Fig 6.1 *Compressed output of satellite image*

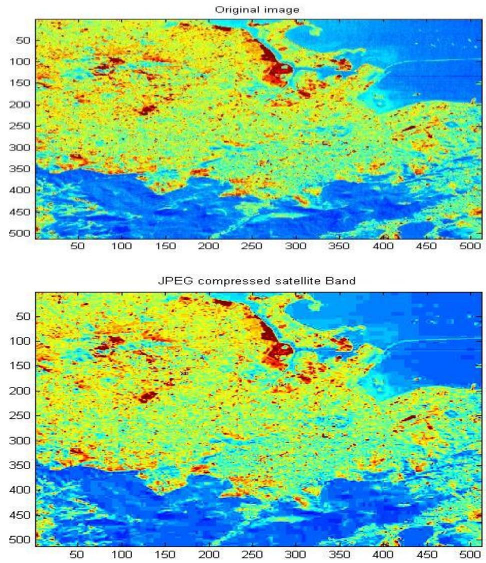


Fig 6.2 *Compressed output of satellite image*

VII. CONCLUSION

In this paper, we demonstrated a simple method that allows ROI compression satellite images using modified JPEG. The ROI compression allows us to process and access data more quickly. The storage space and computation is decreased by implementing ROI compression using above method.

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