HVS-Based Adaptive Scanning for the Compression of Remote Sensing Images

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***Abstract*— In the remote sensing applications compression method is most significant, using mean square error. In the vision based application, the PSNR is higher which shows the good visual quality. In existing compression methods it consider the human visual system for designing natural images, which does not consider the unique feature of remote sensing images. Based on this problem we consider human vision based adaptive scanning scheme for the application of remote sensing image compression. In this first apply the wavelet transform for an image, then establish the retina based visual sensitivity model and then generates the visual weighting mask. Secondly after calculate the scanning order of an weighted mask image in a subband and within a subband, we are using adaptive scanning method. Finally the binary tree codec is used for the encoding and decoding the image. Objective metrics shows that as compared to the other compression method, HAS based compression method provides a good visual quality which is mainly suitable for the vision based application in the case of remote sensing images.**

***IndexTerms*— Adaptive scanning, human visual system(HVS), remote sensing image compression, binary tree coding.**

I. INTRODUCTION

Sensor technology is mainly used for the remote sensing data in the case of remote sensing application to improve the spatial and spectral resolution. Remote sensing images contain more information and cost is increased in present scenario, we are using space borne sensors, which generates the large number of remote sensing images at a rate of several terabytes per day. So data transmission and storage is difficult, hence we have to compress the image using compression technique. The image compression is to reduce the size of an image without degrading the visual quality of an image. The image compression method is used for reducing the image redundancy and store or transmit the data in a significant way. The some common compression technologies, SPECK, JPEG2000, SPIHT, and EZW these compression methods are measured by considering the mean square error(MSE), smaller MSE considers a better compression method, but it does not suitable for all the applications. For remote sensing images human visual system is more favorable. The human visual system is inconsistent with MSE and also it is a complex system. Therefore, it is necessary to study a compression method for remote sensing images from the view of human visual mechanism.

II.PROPOSED HAS METHOD

The novel HAS approach for the compression of remote sensing image is proposed in this paper. The whole compression can be divide into two stage. The first stage is to generate the important weighting mask according to the human visual characteristics, the bits with greater contribution to the visual quality of image scanned in priority. The second stage focuses on designing different scanning orders among subbands and within a subband, respectively. Finally, the binary tree codec is exploited.

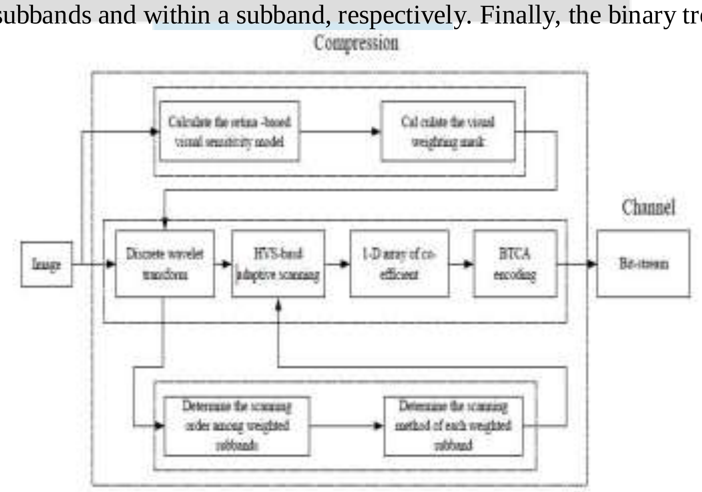


Fig 1: Overall framework of the proposed HAS-based compression method.

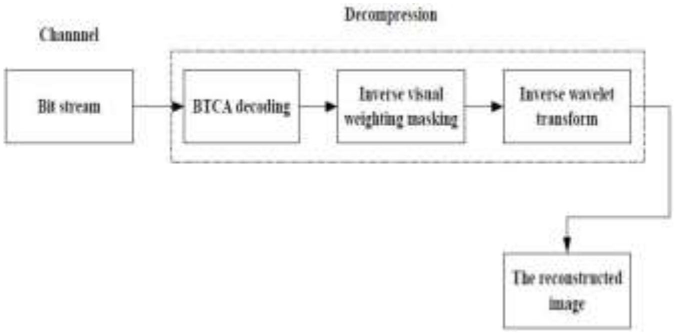


Fig 2: Overall framework of the proposed HAS-based decompression method.

A. Retina-Based Visual Sensitivity model

The human eye uses the retina to collect and process visual information . In the human retina, the spatial distribution of photoreceptors is non uniform, with the highest density at the fovea. This density rapidly decreases with distance from that area. Hence, the local visual frequency bandwidth also falls away. Usually, the visual frequency is used to describe the contrast sensitivity function (CSF), which is utilized to characterize the varying sensitivity of the visual system to 2-D spatial frequencies. The human eye cannot perceive spatial frequencies beyond a given cutoff frequency, i.e., it is not necessary to preserve the information of very high spatial frequency of an image from the perspective of HVS. Therefore, the characteristics of the retina must be considered,

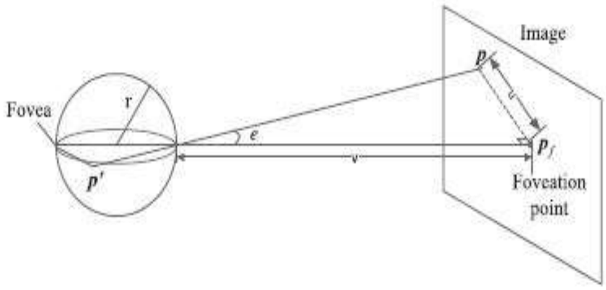


Fig 3: Mapping model of the fovea and the viewing distance

In the figure 3p represents any point in the image, and p0 is the projection onto the retina of point p. pf represents the point we are staring at, i.e., the foveation point, and the fovea is the projection onto the retina of point pf . Here, we assume that the image plane is perpendicular to the line that passes through the fovea and the foveation point pf . From the mapping model, it can be seen that a circle in the image plane centered at pf will be projected to a circle in the retina centered at the fovea. The contrast threshold function in the spatial domain can be represented

$$TF(f,e) = TF_0 \exp\left(\beta f \frac{e+e_2}{e_2}\right) \qquad (1)$$

where f is the spatial frequency, e is the retinal eccentricity, TF_0 is the minimal contrast threshold is the spatial frequency decay constant, e2 is the half-resolution eccentricity constant, and TF_0 (f,e) is the visible contrast threshold as a function of f and e. The best fitting parameter values given are alpha= 0.106, e2=2.3, and TF_0 = 1=64.

For a given eccentricity e, can be used to find its critical frequency or so called cutoff frequency C_f .

$$C_f = \frac{e_2 \ln(\frac{1}{TF_0})}{\beta(e+e_2)} \qquad (2)$$

The visual sensitivity model based on fovea in the spatial domain can be defined as,

$$M_f(v, f, p) = \begin{cases} \dfrac{TF(f,0)}{TF(f,e)} = \exp(-0.0461 f.e) \\ 0, \end{cases}$$

Finally, the visual sensitivity model of it can be determined by the following equation,

$$M(v, p) = \max_{i=1..k}(M_i(v, p)) \qquad (4)$$

B. Weighting Mask

The purpose of the importance weight mask is to guarantee that the bits with larger contribution to the visual quality can be encoded and transmitted in priority. The visual sensitivity is closely related to the viewing distance. The weighting mask can be obtain by the below equation.

$$W(P_i) = \int_0^\infty p(v) M(v, p_i) d(v) \qquad (5)$$

Where p(v) is the probability distribution model .

III. Flow Chart of the Proposed Method.

From the above flow chart it explains the over all of the proposed method. In this first we take the discrete wavelet transform for the image we get transformed image of different levels. After that we have to calculate the retina based visual sensitivity model and visual weighting mask for an image based on contrast threshold and then calculate the energy of each weighted subband, after that determine the scanning order of the subband, the scanning is consider by setting the threshold value, if the energy is less than or equal to threshold means the horizontal scanning can be performed, otherwise the vertical scan can be performed, after this we are getting 1-D coefficients that means 2-D transformed image is converted into 1-D coefficients. This can be applied to an binary tree coding algorithm for encoding we are getting bit stream after this decoding can be done by using BTCA. After we have to take inverse visual weighting mask and inverse DWT finally we are getting reconstructed image with good VSNR.

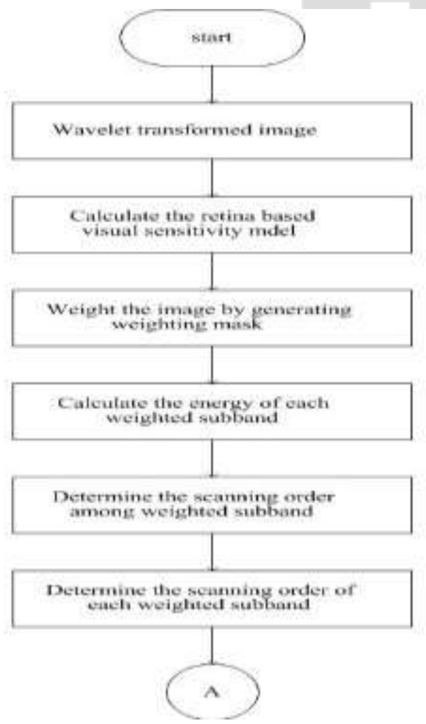


Fig 4: HVS based adaptive scanning method flowchart.

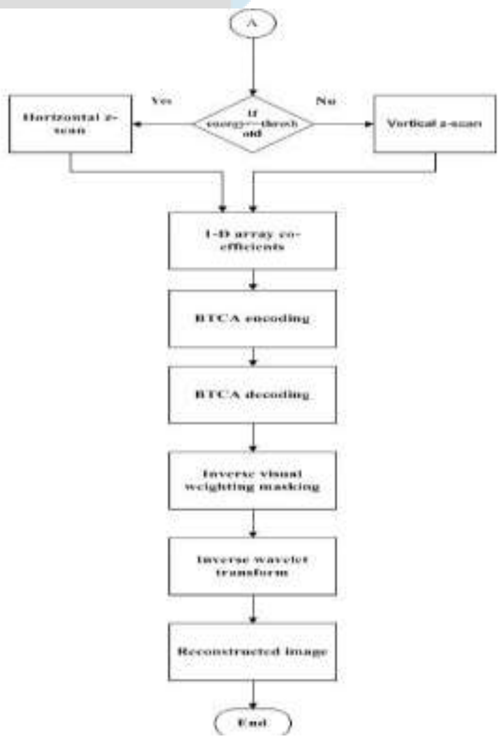


Fig 5: Proposed method flowchart.

IV. Binary Tree Coding

Most of the embedded coding methods are based on quadtree decomposition, such as EZW, SPIHT, and SPECK. However, Shaffer *et al.* pointed out that the coding method based on binary tree decomposition is more efficient and simpler than those based on quadtree decomposition. The state-of-the- art compression approach based on binary tree is proposed in , which developed a new method called BTCA. The BTCA is extremely suitable for the compression of remote sensing images because it can preserve more details.

Function $code = TravDep(\Gamma, t, T_k)$

- If $\Gamma(t)$ has been coded with significant in larger threshold, namely, $\Gamma(t) \geq T_{k-1}$,
  - If $t < S$,
    - $cl = TravDep(\Gamma, 2t, T_k)$;
    - $cr = TravDep(\Gamma, 2t+1, T_k)$;
    - $code = cl \cup cr$.
  - Else
    - $code = \{sign(V(t-S))\}$.
- Else if $\Gamma(t)$ has a significant parent and the brother of $\Gamma(t)$ has just been coded with insignificant, namely, $t > 1$ and $t \bmod 2 = 1$ and $\Gamma(t-1) < T_k$,
  - If $t < S$,
    - $cl = TravDep(\Gamma, 2t, T_k)$;
    - $cr = TravDep(\Gamma, 2t+1, T_k)$;
    - $code = cl \cup cr$.
  - Else
    - $code = \{sign(V(t-S))\}$.
- Else if $\Gamma(t) \geq T_k$
  - If $t < S$,
    - $cl = TravDep(\Gamma, 2t, T_k)$;
    - $cr = TravDep(\Gamma, 2t+1, T_k)$;
    - $code = \{1\} \cup cl \cup cr$.
  - Else
    - $code = \{1\} \cup \{sign(V(t-S))\}$.
- Else
  - $code = \{0\}$.

IV. Quality Evaluation Index

A. VSNR

The visual signal-to-noise ratio (VSNR),VSNR is one of the efficient performance metric to quantify the visuality of an image. It is efficient in both of its low computational complexity and low memory requirement and it operates based on the visual angle and luminance.The VSNR in decibels can be calculated as follows in the equation.

$$VSNR = 20\log_{10}\left(\frac{M(f)}{\beta d_{pc} + (1-\beta)\frac{d_{gp}}{\sqrt{2}}}\right) \qquad (6)$$

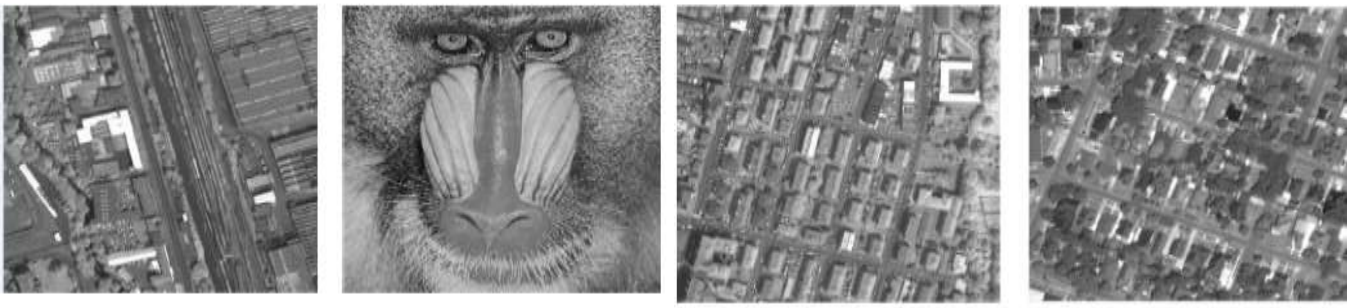
B. MS-SSIM

The MS-SSIM is a multiscale structural similarity technique, which incorporates the versions of viewing situations and is greater flexible than Structural Similarity Index Measure (SSIM). Thus, we adopt the MS-SSIM as an evaluation index in this paper. The equation for MS-SSIM as follows.

$$SSIM(x,y) = [l_N(x,y)]^{\beta_N} . \prod_{j=1}^{N}\left[c_j(x,y)^{\delta_j} s_j(x,y)^{\gamma_j}\right] \qquad (7)$$

Here, c(x,y), l(x,y), and s(x,y) represents the contrast, luminance and structure comparison respectively.

IV. Results and Discussion



(a) Image-1 (b) Image-2 (a) Image-3 (b) Image-4

(a) Image-5 (b) Image-6

Fig 6: Data set images.

We have to take the discrete wavelet transform for an input image, we are getting the subbands as shown in the figure 6. After getting the wavelet transformed image we have to calculate the retina based visual sensitivity model and weighting mask for an image.After that calculate the energy of each subband and than scan the subband elements using adaptive scanning, after the scanning we are getting 1-D co-efficients and than it is applied for binary tree coding for encoding and decoding, we have to take inverse DWT to get the decompressed image as shown in figure.

Fig 7: Input Image

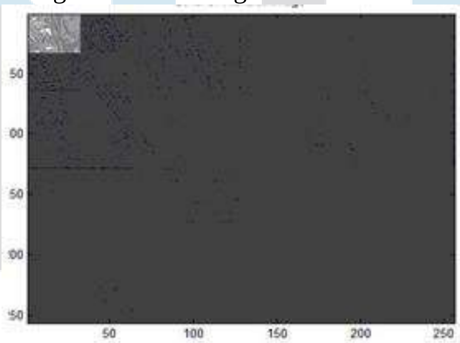


Fig 8: Discrete wavelet transformed image

Fig 9 Decompression Image

Table 1: Comparison of encoded bits

Image name	Image size in bits	Encoded bits	
		BTCA	Proposed
Image1	262144	58105	34230
Image2	57354	48235	36780
Image3	262144	60168	36681
Image4	56882	48112	39166
Image5	57112	47369	37208
Image6	57840	42854	41336

The above table 1 shows the number of bits reduced in the proposed method and binary tree coding method. In this it clearly shows that the no of bits reduced in the proposed method is less as compared to the binary tree coding method.

Table 2: Results for VSNR of the 0.5bpp

Image set	BTCA	Proposed
Image 1	24.2704	49.7762
Image 2	19.9159	43.7727
Image 3	22.1675	46.2875
Image 4	24.4036	48.7755
Image 5	26.2129	49.0494
Image 6	32.6059	47.6954

The above table 2 shows that the VSNR values, this can be calculated using the formula and the table clearly shows that the VSNR is high in the proposed method, The VSNR high means its a having good visual quality. And the BTCA having less VSNR compared to the proposed method.

Table: Results for MS-SSIM of the 0.5bpp

Image set	BTCA	Proposed
Image 1	0.84583	0.99412
Image 2	0.78497	0.99231
Image 3	0.88684	0.99507
Image 4	0.86955	0.99502
Image 5	0.92721	0.99712
Image 6	0.92667	0.99713

The above table 3 shows that the MS-SSIM values, this can be calculated using the formula and the table clearly shows that the MS-SSIM is high in the proposed method. The MS-SSIM high means its a having good visual quality. And the BTCA having less MS-SSIM compared to the proposed method.

V. Conclusion

In this dissertation, we have proposed a human vision adaptive scanning for the compression of remote sensing images and we use different scanning order among the subband are designed. Here we use binary tree coding for encoding the image this will help to a progressive image transmission. The scanning method improve the coding performance. Experimental result shows that, as compared other scan based method, the proposed compression method provide a good VSNR. It is a low complexity. It is very suitable for the vision related applications.

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