New Compression Scheme for Multispectral Images

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Abstract

In this paper, we propose a new method for multispectral image compression that is based on highly correlated relational property taken from a spatial image and its wavelet transform. The highly active regions, such as edges or contour, in the spatial domain are appeared as significant coefficients in the wavelet transform domain; and the low active regions like background as insignificant. These characteristics play an important role in designing the system. The simulation results have shown us that the proposed method has better performance in terms of the reconstructed image quality and the transmitted bit rates. Practically, our system can be successfully applied to the application areas that require of progressive transmission. For some multispectral images with relatively low activity, we have obtained the more good results.

Keyword : Satellite image, Compression, Wavelet

1. Introduction

Satellite Images play an important part in many application fields such as investigation mineral resources, national land development, etc. In order to achieve good result by using them, they have to manage well appropriately. Viewed in the memory management, the fast transmission through network, and the efficient services on web, compression of satellite image will be more important job[1-2].

Image Compression is an important work in image processing. The common feature for most of application using image is, theat without compression, the data to be handled is too large. Recently, a number of the image compression schemes based on wavelet transformation is proposed. The advantage of the wavelet transform over more familiar transforms such as Fourier or cosine lies in the localization of wavelets in both spatial and frequency domains and the multi-resolution nature of wavelets. These features can be properly used for satellite image compression. We propose a new compression scheme for satellite images by texture analysis and region classification in wavelet domain. In wavelet pyramid, mid and high range sub-band region become more stationary random process and are therefore easier to manipulate in a statistical sense. The simulation results show the high compression ratio and good reconstructed image quality.

2. Proposed Compression System

Multispectral sensors measure electromagnetic radiation in different spectral bands, including bands outside the visible spectrum. Data generated by those instruments contain a high degree of redundancy among spectral bands, due to both the characteristics of the sensing mechanism and the imaging environment.

Compression algorithms for video data can achieve extremely high compression ratios that can be accomplished by removing the temporal redundancies among successive frames. Although spectral redundancy is significantly different than temporal redundancy, the main principle remains the same: only a limited portion of the spatial information changes among bands. The proposed method is based on the principle and the relation between some region in spatial and wavelet coefficients in transform domain. The figure 1 shows the proposed system.

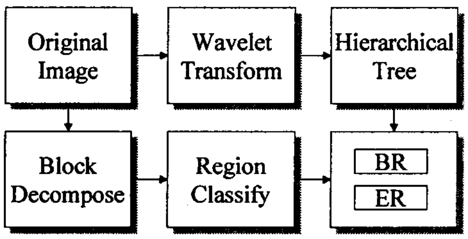


Fig. 1. The proposed system

In the proposed image compression algorithm, first, an image is decomposed into several layers by the wavelet transform, and simultaneously decomposed into $2^n \times 2^n$ blocks. Each block is classified into two regions that are determined by its standard deviation, i.e., background region(BR) and edged region(ER), respectively.

A. Region Classification

Region classification consists of two steps. Firstly, an original image is decomposed into several layers by the wavelet transform, and simultaneously decomposed into $2^n \times 2^n$ blocks. In this paper, size of each block set up 8 $\times$ 8. The simulation showd the best performance when the size of block is set by 8 $\times$ 8. Also, each block is related to 64 coefficients of the wavelet transformd image.

In the second step, we compute the standard deviation(sd) of each block. The value of sd used to determine the characteristics of each block. If the value is small, the region can be regard as low activity region, and is classified to BR. Otherwise, if the region has big sd, the region high activity region, and ER.

B. Quanization

The quantization is the only stage that there is actually any loss of the data. Therefore, this stage have an influence on the quality of the reconstructed image. A well-designed quantization scheme will have higher image quality for the same size compressed file. We propose a fairly simple quantization so as to get good result.

C. Image Compression

The region with low activity in the spatial domain do not only appears as insignificant coefficients in the wavelet domain but also has little influence in the reconstructed image. The amount of bits to be generated for these regions is feeble compared to total bits. On the other hand, the highly activity regions are related to significant coefficients, which yield much influence to image reconstruction. Observably, the high activity regions are mostly linked to edges or boundaries of images. The objectives of our proposed image compression algorithm is to obtain a high compression rate using those relational properties. To accomplish our objective, BR regions are encoded by color information coding method which is similar to the conventional object oriented coding(OOC); this scheme is appropriate to represent the region with low activity. In addition, a technique similar to the conventional bit plane coding is applied to ER region; this scheme has an effective property to represent significant coefficients by connecting quantization stage. Moreover, this method is feasible to implement a progressive transmission by simple operation.

3. Compression Method for Each Region

In this section, we discuss two coding techniques, texture modeling for BR and proposed coding for ER.

A. Texture Modeling

In the early "second generation" coding systems, some investigators employed model-based concepts to take advantage of image phenomenology and human visual system models. These methods, described as contour-texture oriented method, used image segmentation algorithms to define a complete partition of an image. The image is then coded in two channels, the region boundaries (contours) and the region textures. Some methods using these coding system have been presented and modified by wavelet-based coding researchers.

However, in above all system, the main difficult problem is how to express segmented boundary. Moreover, bit rates needed to transmit it are too much. In this system, we apply texture-modeling technique [4] to square regions with low activity so that does not take account of processing segmented boundary. We can consider that these regions consist of wide homogeneous area. To apply the texture modeling, we consider a simple standard deviation(SD) model that achieves local correlation by expressing the value of a sample as a only SD of the square region. This model can be written as

$$WC_{x,y,k} = GM_k \pm \sigma_k \qquad (1)$$

Where,

$WC_{x,y,k}$: coefficient at (x,y) position of the kth region

GM_k : geometric mean of the kth region

σ_k : standard deviation of the kth region

In this model, the texture parameters that must be transmitted to the receiver are the geometric mean, the standard deviation and additional information that need to make more accurate reconstruction. We confirm that this simple model is adequate to produce realistic homogeneous textures through simulation.

B. BitPlane Coding based on Quantized Step

ER regions regard as important parts of an image such as edges or contour of objects. However, because they include an abundance of significant coefficients, it needs to a lot of bit stream to represent them. We propose a bitplane coding using quantized step, similar to conventional bitplane method. The proposed method shows that efficiently controls the above problem, and possibility of progressive transmission.

```
① Initialization

  l = 1;
  n = ⌊ log2( max_{j∈p} (|C_j|) ⌋ ;
  initial threhold  T_l = 2^n
  initial quantization value  Q_l = T_l

  for (all coefficient in a hierarchical tree; the index of them = p) {
       tag[p] = 0;
       LSP[p] = C_p ;
       // or LSP[p] = {C_p | C_p ≥ T}
       // The threshold T can be changed
          by user request or network traffic
  }

② Coding and Refinement Process

  for (satisfy given condition or n ≥ 1) {

    // coding pass
    for (each entry C_p in the LSP) {
          if ( C_p ≥ T_l ) {
                if (tag[p] = 0) {
                    output the sign of C_p and  Q_l or n;
                    tag[p] = 1;
                }
                else output  Q_l ;

                C_p = C_p - Q_l ;
                LSP[p] = C_p ;
          }
    }

    // refinement and quantization-step pass
    l = l + 1;  n = n - 1;  T_l = 2^n;  Q_l = T_l;
  }}
```

4. Simulation Result

In order to verify efficiency of proposed method, we have applied this coding scheme to a arbitrary region of Landsat-TM image that is according to spatial resolution with 256 × 256. The filter for wavelet decomposition is 5-tap QMF of Johns [5].

Figure 3 shows arbitrary region of 3rd band of Landsat-TM and its block map. In the map, the symbol '-' means BR, and '*' ER, resspletively. In most of cases, all bands in multispectral have nearly identical block map.

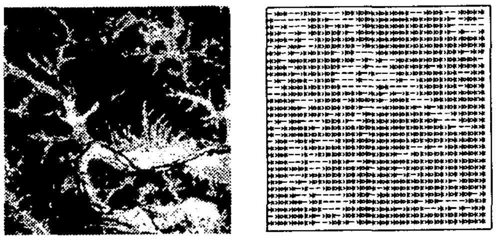


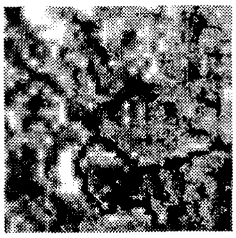
Fig 3. Landsat-TM and its block map

As shown in table 1, the performance of proposed scheme is consistently improved 2 to 3 dB compared to the original zerotree algorithm[3]. Especially the result for images with a little activity in spatial domain appears exceedingly good performance. Regions with wide homogeneous feature can be coded by texture modeling that only requires little bits.

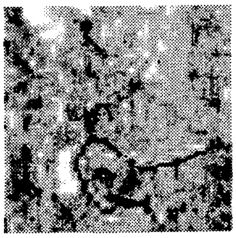
Table 1. Coding Result

bpp	EZW	Proposed
0.5	32.3	35.4
0.1	24.8	27.5

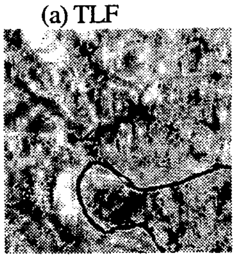
The progressive reconstruction can be implemented by proposed algorithm. Fig. 4 shows the process. In the Figure, the symbol 'TLF' stands for 'The Lowest Frequency'.



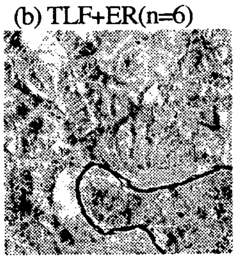
(a) TLF



(b) TLF+ER(n=6)



(c) TLF+ER(n=4)



(d) TLF+ER(n=2)

Fig. 4. Progressive Reconstruction

5. Conclusion

The proposed compression system for multispectral image, using the relationship between the properties of the spatial domain and wavelet transform domain, showed that efficient compression is possible in terms of visual and progressive transmission. Especially at the very low bit rates, this scheme is superior to the zerotree methods, the traditional and general algorithm for image compression, in both reconstructed image quality and transmitted bit rates. The system can be efficiently applied to application areas like efficient storage, and retrieval of images in the context of multimedia databases.

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