Satellite Image Compression Technique Using Noise Bit Removal and Discrete Wavelet Transform

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ABSTRACT: *A feature of satellite images is the presence of noise, where this noise often requires preprocessing of the images by a denoising method adapted prior to their compression, storage and transmission. In this work to improve the compression scheme, we are interested in image compression by discarding noisy bits from the satellite image and discrete wavelet transform (DWT). This method was tested on various satellite images; this type of compression has allowed us to determine the quality of the reconstructed images (PSNR) and the compression ratio (CR) according to the corresponding of denoising method. A comparative study was conducted to determine the methods leading to the best possible results.*

Keywords: Satellite Image, Denoising, Compression, DWT

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1. Introduction

With the development of information technology, high performance instruments have appeared on the market and powerful methods have been implemented to meet the needs of acquisition, storage and processing of information. [1] This development generated applications which involve transmission and data archiving increasingly large. It became essential to compress the data to reduce them to a more easily harvestable size. The methods used for compression such as wavelet and discrete cosine transform have been proposed, but unfortunately, the performance of these techniques degrade in the presence of noise, which degrades the correlation between pixels. In this paper, a filtering scheme by different filters has been proposed to eliminate the effects of noise hybridized with the wavelet transform and adaptive vector quantization, in our work, we apply the discrete wavelet transform (DWT) on the filtered image, in this case, the DWT is better than the methods based on the DCT, such as the JPEG algorithm. [2] The purpose of transformation is to provide information easily compressible; we can subsequently make a vector quantization of each sub band according to its importance. This paper is organized as follows: the second section is devoted to the proposed method. In Section 3, we present some experimental results. Finally, we offer some conclusions and remarks in Section 4.

2. Method

2.1 Reduction of Noise in an Image

Filtering

Sources of image noise are many and varied; Filtering is one of the most common methods of reducing noise in an image. Its purpose is to reduce the amplitude of noise-related disturbances. The filter can be defined as the process of replacement of a pixel by a value which is a function of data near the pixel [3].

2.1.1 Average Filter

The aim is to achieve an average gray level around the central pixel. An application of linear filter can replace each point by the average of its neighbors.

$$\frac{1}{9} * \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$$

2.1.2 Gaussian Filter

It is also a low pass filter. A two dimensional Gaussian is given by the following expression:

$$g(x,y) = \frac{1}{2\pi\sigma} exp\left(\frac{x^2+y^2}{2\sigma^2}\right) \tag{1}$$

σ: Used to adjust the degree of filtering. This filter attaches great importance to the pixels around the central pixel, and decreases the importance gradually when we move away from the pixel. The following mask allows a Gaussian weighting.

$$\frac{1}{16} * \begin{pmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{pmatrix}$$

2.1.3 Median Filter

Median filter take the value of gray levels between the population of gray levels in two equal effective. It is thus to sort the neighboring pixels of the central pixel and taking the median of the ordered set.

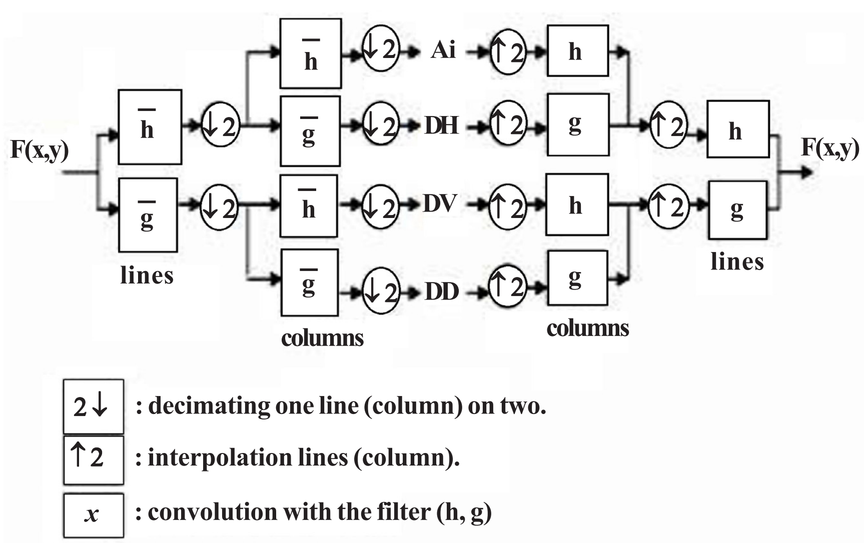

Figure 1. Multi-Resolution Analysis in Two Dimensions

2.2 Discrete Wavelet Transform (DWT)

The discrete wavelet transform is a multi-resolution/multi-frequency representation. This principle is illustrated in Figure 1. This gives a decomposition of the image into sub-bands with different filters (low pass h and high pass g). This requires the use of a separable two dimensional DWT (columns + lines). The input image is decomposed at each time in four sub-images (approximate image BB, horizontal detail BH, vertical detail HB and detail diagonal HH) with different low-pass and high-pass filters. The reconstruction is done using quadrature mirror filters (QMF) [4], this phase is the inverse of the decomposition operation (replacing the low-pass and high pass filters with their mirrors filters) and the decimation operation is replaced by the interpolating operation of adding a zero between each pair of coefficients.

2.3 Vector Quantization

Vector quantization has the same operations as the Scalar Quantification except that the partition is done in R^k.

R: Set of real numbers.

k: Size of the vectors used.

It concerns the representation of a vector x, with k components (those components values are continuous and real $x \in R^2$) by a vector belonging to a finite set $Y = \{yi \in R^k, i = 1, 2,...N\}$ called a dictionary. N is the size of dictionary [5]. The *VQ* is divided into two parts, an encoding portion and a decoding portion, the role of the encoder for any vector x is the input signal to find in the dictionary Y the vector code y closest. It is only the address of the selected vector code y to be transmitted. The decoder has a replica of the dictionary and consults it to provide the vector code index corresponding to the received address [6].

2.4 Entropy Coding

To measure the amount of coded information in a message information theory uses the term "entropy". More the entropy of a message is large, it contains more information [7]. The entropy of a symbol in a message is defined as:

$$nb = -\log_2(p) \tag{2}$$

With: nb: number of bits assigned to the symbol.

P: probability of occurrence of the symbol in the message. The entropy of a message is simply the sum of the entropies of all symbols of the message, if the probability of the symbols of a message was known, there should be a way of encoding symbols, so that the message takes up less space [8].

2.5 Program Structure

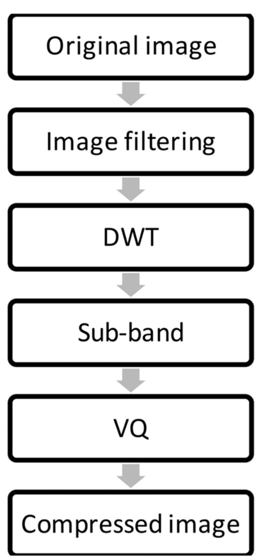

Figure 2. Program Structure

In our study, after discarding noisy bits from the satellite image the DWT is used to obtain sub-images according to an architecture pyramid. The coefficients representing the smoothed band and sub-band details are treated by vector quantization. After the quantization, the latter undergo entropy coding of the operation followed by transmission or storage. The functional diagram of the compression operation is illustrated in figure 2.

3. Results

The algorithm realized in C++ Builder v6.0 to code and to decode an image excerpt from the satellite SPOT, the images are subjected a wavelet decomposition on three levels (figure 3). Once the decomposition is complete, we assembling the details of each decomposition level [(D1H, D1V, D1D), (D2H, D2V, D2D), (D3H, D3V, D3D)].

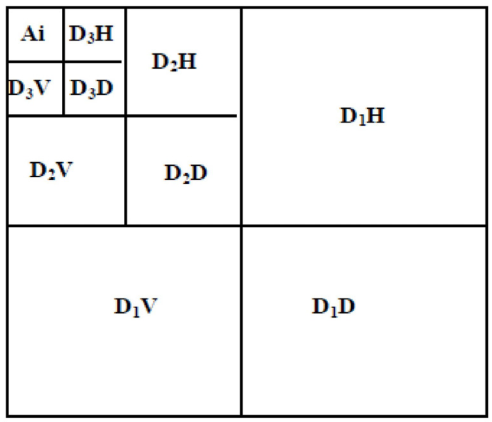

Figure 3. Decomposition of a tri-level image

We present different results in terms of Peak signal to noise ratio PSNR in (db) and compression ratio CR (%). These parameters are expressed by the equations 4 and 5.

$$PSNR = 10 \log 10 \ \frac{255^2}{MSE} \tag{3}$$

$$MSE = \frac{1}{n * m} \sum_{i=1}^{n} \sum_{j=1}^{m} (x_i - y_j)^2 \tag{4}$$

$$CR(\%) = 100 * 1 - \left(\frac{final\ size}{initial\ size}\right) \tag{5}$$

n, m: Length and width of the image.

x_i, y_j: Value (gray level) of the original image and the reconstructed image. We apply the compression algorithm. And we vary filters; the results of our simulation are presented in the Table 1. It is clear that the coefficients of the approximation should be quantified as finely as possible.

4. Conclusion

In general, it can be said that the proposed approach can achieve very good results in points of quality of the reconstructed images, execution time and compression rate; it can dramatically reduce the amount of data contained in the images while maintaining their original properties. These results depend on the denoising method, wavelet compression and the nature of images.

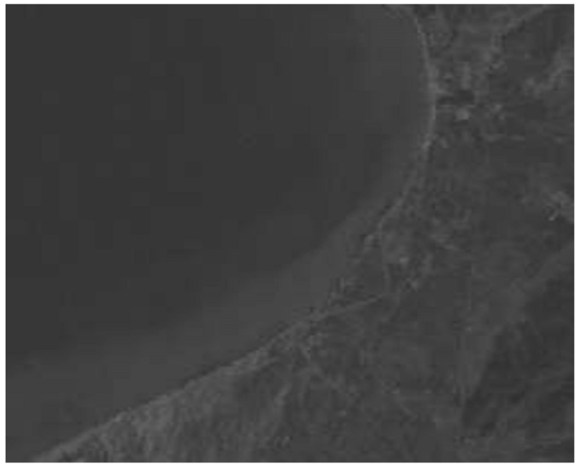

Figure 4. Original Satellite Image (1)

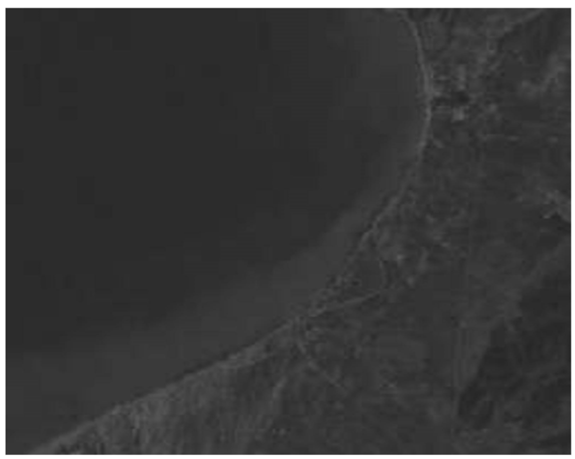

Figure 5. Satellite Image Reconstructed (1)

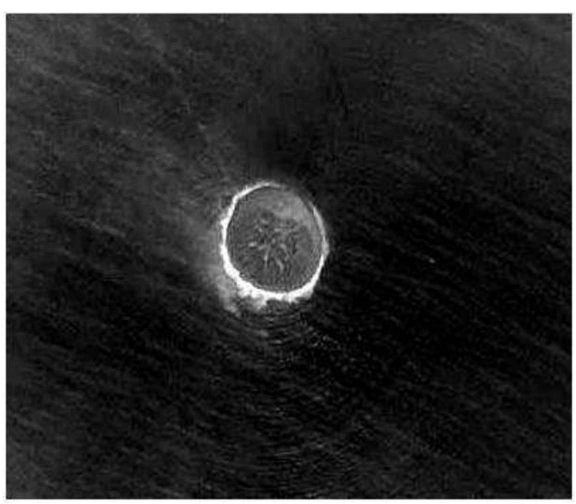

Figure 6. Original Satellite Image (2)

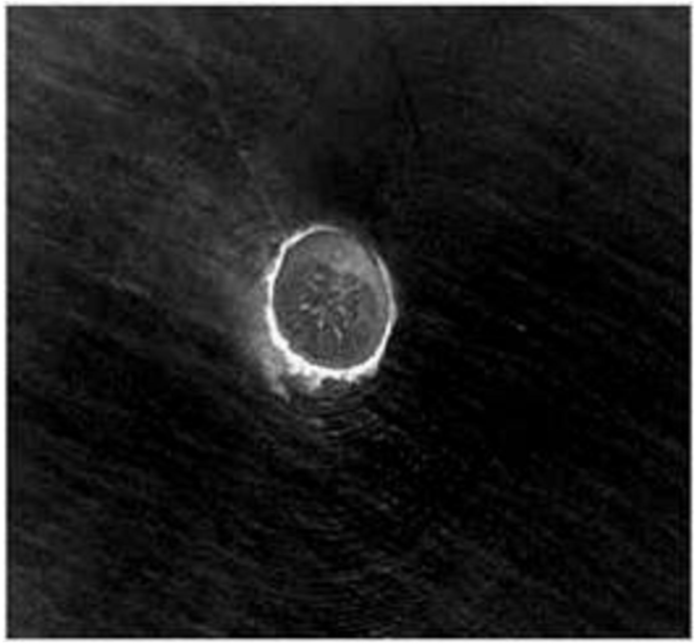

Figure 7. Satellite Image Reconstructed (2)

Evaluation	Filtering Methods	Image Satellite (1)	Image Satellite (2)
PSNR (db)	Average Filter	32.54	32.18
	Gaussian Filter	33.55	33.70
	Median Filter	33.27	33.32
T (%)	Average Filter	93.85	93.75
	Gaussian Filter	93.87	93.79
	Median Filter	93.78	93.76

Table 1. Table of Results With Satellite Image

References

[1] Held, G., Marshall, T. R. (1999). Data and image compression tools and techniques. John Wiley & Sons, Chichester, 432 p.

[2] Barlent, M. (1994). Wavelets in image communication. Edition ELSEVER.

[3] Chang, Bin, Y., Vetterli, M. (2006). 'Adaptive wavelet thresholding for image denoising and compression, *IEEE Trans. On Image Processing*, vol. 9 (9) 1532- 1546, (September)

[4] Averbuch, A., Lazar, D., Israeli, M. (1996). Image compression using wavelet transform and multiresolution decomposition. *IEEE Transactions on Image Processing*, 5 (1) 4-15.

[5] Kin, K., Paik, R. H. (1995). still Image Coding Based on Vector Quantization and Fractal Approximation, *IEEE Transaction on Image Processing*, vol. 5 (5).

[6] Hamzaoui, R., Saupe, D. (2000). Combining fractal image compression and vector quantization. *IEEE Transactions on Image Processing,* vol. 9 (2) 197-208.

[7] Kin, K., Paik, R. H. (1995). still Image Coding Based on Vector Quantization and Fractal Approximation, *IEEE Transaction on Image Processing*, vol.5 (5).

[8] Rabbani, M., Santa Cruz, D. (2001). JPEG2000 image coding standard. *In*: Proc. IEEE International Conference on Image Processing. ICIP ’01, Thessaloniki, Greece, (October).