THE FOURIER TRANSFORM FOR SATELLITE IMAGE COMPRESSION

Khaled SAHNOUN and Noureddine BENABADJI

Laboratory of Analysis and Application of Radiation (LAAR)
Department of Physics, University of Sciences and Technology of Oran (USTOMB)
B.P. 1505, El M'nouar, 31024, ORAN, Algeria

sahnounkhaled@hotmail.fr,benanour2000@yahoo.com

ABSTRACT

The need to transmit or store satellite images is growing rapidly with the development of modern communications and new imaging systems. The goal of compression is to facilitate the storage and transmission of large images on the ground with high compression ratios and minimum distortion. In this work, we present a new coding scheme for satellite images. At first, the image will be downloaded followed by a fast Fourier transform FFT. The result obtained after FFT processing undergoes a scalar quantization (SQ). The results obtained after the quantization phase are encoded using entropy encoding. This approach has been tested on satellite image and Lena picture. After decompression, the images were reconstructed faithfully and memory space required for storage has been reduced by more than 80%
.

KEYWORDS

Compression, Encoding Entropy, FFT, Scalar Quantization, Satellite

1. INTRODUCTION

Compression of satellite images is a set of techniques and methods used to reduce the volume of data without losing important information. The reduction will take place either by lossless algorithm which the original data will be found, either lossy algorithm where the retrieved data after compression are reasonable reconstruction of the original data. [1] Reduce the amount of data used to store more information on a single media or take less time for data transmission to the ground. [2]In some cases the volume of data is such that it would be almost impossible to manage without using a compression operation with the best possible compromise between compression ratio and the quality of reproduction of images. [3] In this paper we propose a technique based on the Fourier transform and scalar quantization (SQ) to drastically increase the compression ratio, while maintaining a satisfactory quality of the reconstructed image. This paper is organized as follows Fourier transforms is illustrated in section two. The proposed scheme is presented in part three. Simulation results are given in section four and finally a conclusion in Part Five.

David C. Wyld et al. (Eds) : CST, ITCS, JSE, SIP, ARIA, DMS - 2014
pp. 119–125, 2014. © CS & IT-CSCP 2014 DOI : 10.5121/csit.2014.4112

2. FOURIER TRANSFORM

The Fourier transform, also known as frequency analysis or spectral involved in the implementation of many digital techniques for processing signals and images. [4] It is found in applications such as direct harmonic analysis of musical signals and vibrations, but also reduces the rate coding of speech and music (mp3), voice recognition, improving the quality of images, compression, and digital transmissions. Applying a Fourier transform give a complex image. [5] In general, we calculated the module Fm and the phase Fp of the source image, and we represent the module. These two images can be defined as following:

$$Re\big(F(f)(x,y)\big) = Fm(x,y)\cos\big(Fp(x.y)\big) \rightarrow (1)$$

$$Im\big(F(f)(x,y)\big) = Fm(x,y)\sin\big(Fp(x.y)\big) \rightarrow (2)$$

Where Re and Im denotes the real and imaginary parts. One then finds that Fp is not unique. In general, to represent the transform, it is only the module.

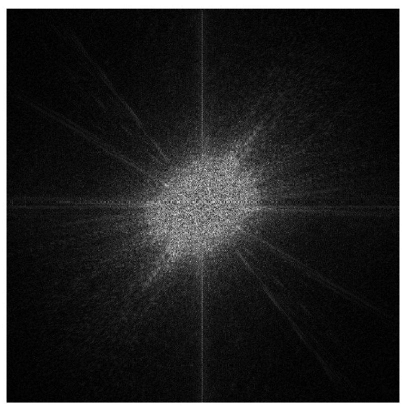

Figure 1. Module blue channel butterfly

Note that the image is square, we completed the butterfly image with black to make it square. In addition, we work more frequently with square images. [6]

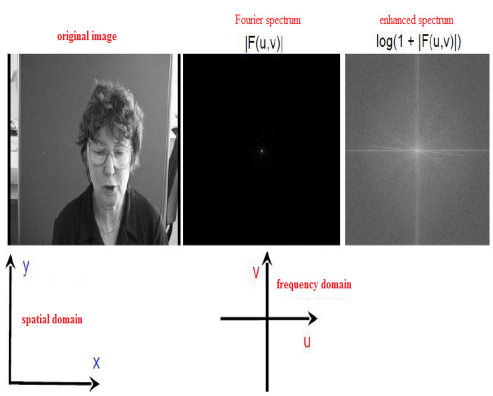

Figure 2. Fourier Transform

The Fourier transform of a real image can be expressed as follows:

$$F(u,v) = \frac{1}{mn}\sum_{x=0}^{m-1}\sum_{y=0}^{n-1} f(x,y).e^{-2\pi i\left(\frac{ux}{m}+\frac{vy}{n}\right)}$$

With u and v = 0..N-1 → (3)

Reverse:

$$f(x,y) = \sum_{u=0}^{m-1}\sum_{v=0}^{m-1} F(u,v).e^{2\pi i\left(\frac{ux}{m}+\frac{vy}{n}\right)}$$

With x and u = 0..N-1→ (4)

The variables u and v used in the equation (3) are variable frequency (frequency domain), x and y used in the equation (4) are variable in the spatial domain. F(u,v) Is often represented by its amplitude and phase, rather there are the real and imaginary parts, the formula is given by:

$$amplitude\left(F(u,v)\right) = \sqrt{R^2(u,v) + I^2(u,v)} \rightarrow (5)$$

$$phase\left(F(u,v)\right) = \tan^{-1}\left[\frac{I(u,v)}{R(u,v)}\right] \rightarrow (6)$$

3. PROPOSED APPROACH

The main philosophies of our image compression technique based on the fast Fourier transform (FFT). The general architecture of the system coding of our method relied primarily on the steps shown in the following figure:

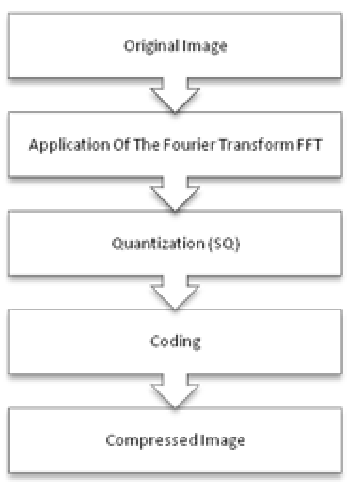

Figure 3. The steps of the proposed method

3.1. Read the image source

The input image is satellite picture, the size will be equal to 2^n, in our case it is 2^8 (256 * 256).

3.2. Calculate the Fourier transform (2D FFT) for this image

The type of data returned by the FFT is complex, which contains real and imaginary parts. The real part is the amplitude, and the imaginary part is the phase. In the proposed method, just the amplitude is concerned, which is the only party represented in the surface and the displays of the transformation results.

3.3. Quantization

The compression technique by quantization can be improved either by acting directly on the step of constructing the dictionary or by acting on the quantization step of the input pixels. In this method, an improvement of the second step has been proposed (input vector). The scalar quantization of each is the approximate value of the random signal x(t) by a value that belongs to a finite set of codes {y1, y2, ..., yl}. At any amplitude x in the interval [xi-1, xi], there corresponds a quantized value yi situated in that Interval. [8]

3.4. Coding

In the coding phase we used the RLE encoding. It is a compression mode of the simplest and oldest, it is both easy to implement and fast execution. The algorithm is to identify and remove redundant information by encoding more compact form any sequence of bits or characters is replaced by the same number of occurrences of a couple, bit or character repeated. The image coding by RLE method coded the sequence of identical gray pixel values, assigning the three parameters, the position (x, y) of the first pixel in the sequence, the gray value of the first pixel and the length of the sequence. Finally the Huffman algorithm is applied which is a compression algorithm capable of generating variable length codes to a whole number of bits. This algorithm can achieve good results, but it should be kept the codebook used between the compression and decompression. [9]

4. EXPERIMENTAL RESULTS

4.1. Evaluation of compression and loss

Compression ratio (T):

$$Q = \frac{\text{initial size}}{\text{final size}} \rightarrow (7)$$

$$T = \frac{1}{Q} \rightarrow (8)$$

Compression gain:

$$G = \frac{\text{initial size} - \text{final size}}{\text{final size}} \rightarrow (9)$$

Mean Squared Error:

$$MSE = \frac{1}{N} \sum_{i=0}^{N-1} (ncomp(i) - n(i))^2 \rightarrow (10)$$

Peak Signal to Noise Ratio

$$PSNR = 10 \log_{10} \frac{255^2}{MSE} db \rightarrow (11)$$

A powerful compression algorithm has a gain of maximum compression and a minimum mean square error. [7] The compression ratio, the mean squared error and PSNR are calculated by equations (8) and (6), (11). The proposed scheme has been tested by satellite image and Lena picture.

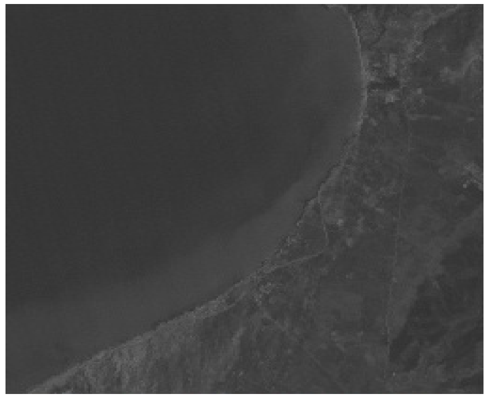

Figure 4. Original satellite image (1)

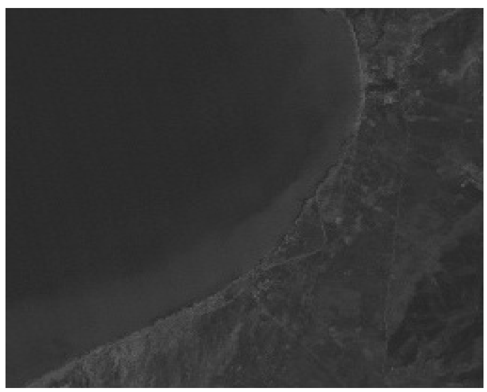

Figure 5. Satellite image reconstructed (2)

Figure 6. Original Lena image

Figure 7. Reconstructed Lena image

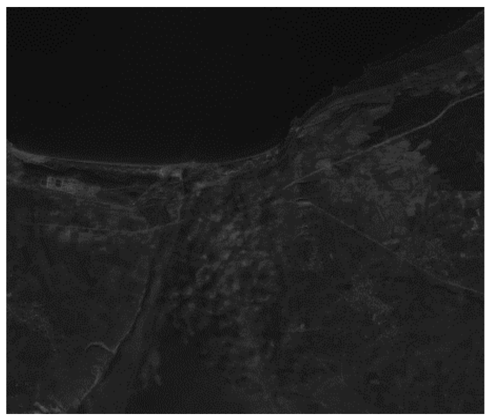

Figure 8. Original satellite image (2)

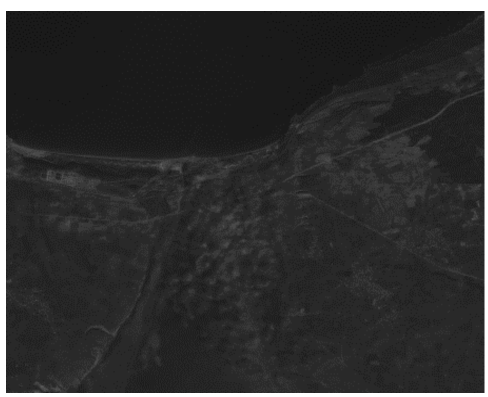

Figure 9. Satellite image reconstructed (2)

Table 1. Table of results with satellite image and Lena picture 256 * 256

Image	Lena	Satellite (1)	Satellite (1)
MSE	11.67	9.92	8.87
PSNR (db)	37.49	38.20	33.79
T (%)	65.52	87.27	76..3

5. CONCLUSIONS

In this paper we have presented an approach for still image compression based on the Fourier transform and scalar quantization (SQ) and also the entropy encoding. The compression and decompression algorithm that we have developed in this article is able to compress satellite images and grayscale picture with high compression ratio and return with a better quality. Thus, tests on Lena image and other images show the superiority of this algorithm with respect to other compression methods.

REFERENCES

[1] LAHDIR MOURAD “new approach to image compression based on wavelet and fractal for Meteosat image application” PhD Thesis University Mouloud Mammeri UMMTO, Tizi-Ouzou Algeria 2011.

[2] STEVEN PIGEON “Contributions to the Data Compression” PhD Thesis University of Montreal Canada 2001.

[3] SYLVAIN ARGENTIERI ”Introduction to image compression” Institute Of Robotics And Intelligent Systems Paris 6 France 2009 .

[4] BENJAMIN HARBELOT YOAN “Project mathematical Fourier Transform” University of Burgundy France 2010.

[5] ERIC FAVIER. ‘’Image analysis and processing, principles of computer vision’’. ENISE France.

[6] A. AMAAR, E.M. SAAD, I. ASHOUR AND M. ELZORKANY Electronics Department, National Telecommunication Institute (NTI) Image “Compression Using K-Space Transformation Technique” Recent Researches in Communications, Electronics, Signal Processing and Automatic Control 2012.

[7] R.KUMAR, K.SINGH, R.KHANNA Dept. of ECE Thapar University, Patiala “Satellite Image Compression using Fractional Fourier Transform” International Journal of Computer Applications (0975 – 8887) Volume 50 – No.3, July 2012.

[8] A. MOULAY LAKHDAR, M. KANDOUCI, B. BELGHEIT “Image compression by wavelet transforms and adaptive vector quantization” University Of Bechar and Department of Electronic faculty of Science & Engineering University Djilali Liabes. IMAGE conference Biskra Algeria 2009.

[9] ERIC FAVIER “image compression Part H” National School of engineers Saint-Etienne France 2008.