Image Compression and Decompression using nested Inverse Fourier Transform and Fast Fourier Transform

Rekha Nair
Centre for Development of Advanced Computing,
Gulmohar Cross Road No.9, Juhu, Mumbai – 49, India
e-mail: rekhap@cdac.in

Nirmala Salam
Centre for Development of Advanced Computing,
Gulmohar Cross Road No.9, Juhu, Mumbai – 49, India
e-mail: nirmala@cdac.in

***Abstract*— Image compression is the reduction or elimination of redundancy in image data representation in order to achieve savings in storage and communication. In this paper we propose a method for image compression and decompression using nested IFFT and FFT which works on both color and grey images. This technique is simple in implementation and utilizes less memory and also requires less computational time.**

Keywords*— *compression; decompression; fft; ifft; image processing

I. Introduction

The rapid growth of digital imaging applications, including desktop publishing, multimedia, teleconferencing, including image database, image communications has increased the need for effective and standardized image compression techniques.

Raw images need large amounts of disk space which seems to be a big disadvantage during transmission & storage. The purpose of image compression is to reduce the amount of data required for representing sampled digital images and thereby reduce the cost for storage. Image compression is achieved by removing data redundancy while preserving information content. For example, a color image with a resolution of 1024 x 1024 picture elements (pixels) with 24 bits per pixel would require 3.15 M bytes in uncompressed form.

Data compression techniques can be broadly classified into two classes called lossless and lossy compression techniques. In lossless compression techniques, no information regarding the image is lost, i.e. the reconstructed image from the compressed image is identical to the original image in every sense. Whereas in lossy compression, some image information is lost, i.e. the reconstructed image from the compressed image is similar to the original image but not identical to it.

There are several compression formats available for the compression of color images, such as JPEG, JPEG2000 [1], and PTC [2]. Similarly, there are several compression formats for binary text and diagrams: CCIT G4 (fax), JBIG2, and BLC [3]. The method proposed in [4] gives good results but is hardware dependent. Neural networks are also used for compression of images [5], but they have low compression rates.

II. Fast Fourier Transform (FFT) and Inverse Fourier Transform (IFFT))

The Fourier Transform is an important image processing tool which is used to decompose an image into its sine and cosine components. The output of the transformation represents the image in the Fourier or frequency domain, while the input image is the spatial domain equivalent. In the Fourier domain image, each point represents a particular frequency contained in the spatial domain image. Image reconstruction using FFT/IFFT is also possible as proposed in [8].

The Fourier Transform is used in a wide range of applications, such as image analysis, image filtering, image reconstruction and image compression.

The Fourier transformation is generally needed to transform a signal from the spatial dimension into the frequency dimension. The frequency domain representation is exactly the same signal, in a different form. Using the Inverse Fourier transformation the converted signal can be restored from frequency dimension.

The Fast Fourier Transform (FFT) is another method for calculating the DFT. While it produces the same result as the other approaches, it is incredibly more efficient, often reducing the computation time by hundreds.

The Fourier Transform produces a complex number valued output image which can be displayed with two images, either with the real and imaginary part or with magnitude and phase. In image processing, often only the magnitude of the Fourier Transform is displayed, as it contains most of the information of the geometric structure of the spatial domain image. However, if we want to re-transform the Fourier image into the correct spatial domain after some processing in the frequency domain, we must make sure to preserve both magnitude and phase of the Fourier image

III. Proposed Algorithm

The DFT is the sampled Fourier Transform and therefore does not contain all frequencies forming an image, but only a set of samples which is large enough to fully describe the spatial domain image. The number of frequencies corresponds to the number of pixels in the spatial domain image, i.e. the image in the spatial and Fourier domain is of the same size.

For a square image of size N×N, the two-dimensional DFT is given by:

$$F(k,l) = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} f(i,j) e^{-i2\pi\left(\frac{ki}{N}+\frac{lj}{N}\right)} \quad (1)$$

where f(i,j) is the image in the spatial domain and the exponential term is the basis function corresponding to each point F(k,l) in the Fourier space. The equation can be interpreted as: the value of each point F (k,l) is obtained by multiplying the spatial image with the corresponding base function and summing the result.

The basis functions are sine and cosine waves with increasing frequencies, i.e. F (0,0) represents the DC-component of the image which corresponds to the average brightness and F(N-1,N-1) represents the highest frequency.

In a similar way, the Fourier image can be re-transformed to the spatial domain. The inverse Fourier transform is given by:

$$f(i,j) = \frac{1}{N^2}\sum_{k=0}^{N-1}\sum_{i=0}^{N-1} F(k,l) e^{i2\pi\left(\frac{ki}{N}+\frac{lj}{N}\right)} \quad (2)$$

In this proposed method (as shown in Figure 1), we first apply nested Inverse Fast Fourier Transform to the original color or grey image. The original image gets compressed and it has been found that the compression ratio achieved by this algorithm is more than the conventional methods like jpeg etc.

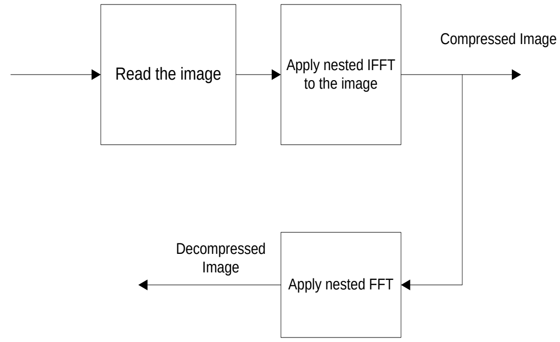

Figure 1. Block Diagram of the proposed algorithm

The compression is evaluated based on the overall compression ratio (CR) which is defined as:

CR = size of the input or original image / size of the output or compressed file

For decompression, we apply nested Fast Fourier Transform to the compressed image. The image gets decompressed and is almost similar to the original image.

IV. Experimental results

Various grayscale and color images were used as test images. All the image files that we have tested are of jpeg format and of different sizes. The compression ratios obtained are tabulated in Table I.


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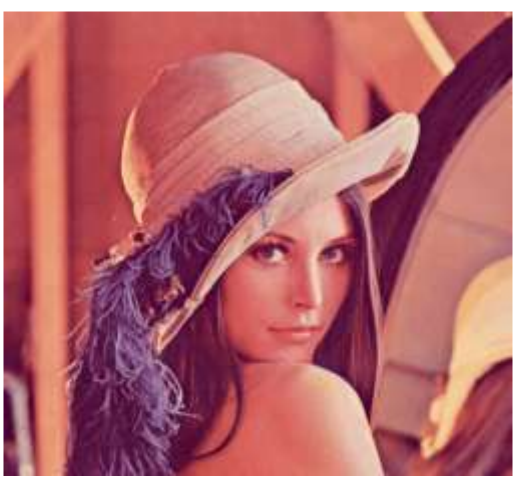

Figure 2. Original Images

Figure 3. Decompressed Images

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CONCLUSION

This paper proposes a compression algorithm which, while being computationally inexpensive, reduces the image size considerably. The decompression algorithm is then implemented on this compressed image. The results suggest that fairly good compression and decompression is obtained in very less computational time. Also the decompressed image is as good as the original image.

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TABLE I. COMPRESSION RATION OF VARIOUS IMAGES

Image name	Original Size	Compressed size	Compression Ratio
Blue hills	27.8kb	8.03kb	3:1
Water lilies	81.8kb	8.03kb	10:1
Text Examples	91.6kb	4.32kb	21:1
Lena	44.3kb	4.61kb	9:1

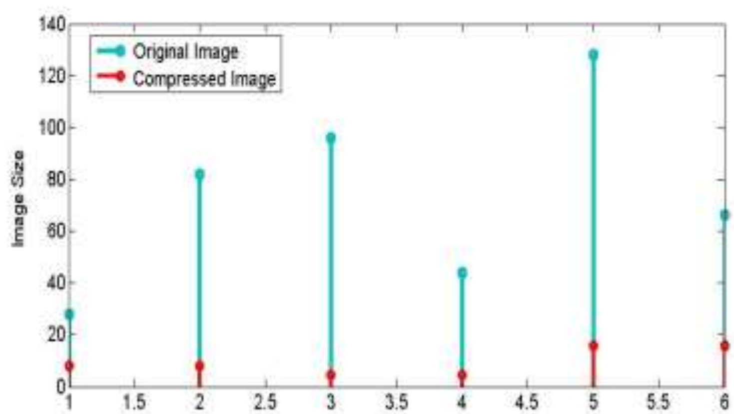

Figure 4. Original vs Compressed Image