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Image Compression using Discrete Cosine Transform, Block Truncation Coding and Gaussian Pyramidal Approach

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Abstract**—**Image compression is the natural technology for handling the increased spatial resolutions of today's imaging sensors and evolving broadcast television standards. Image compression plays an important role in many important and diverse applications including conferencing, remote sensing, document and medical imaging, and the control of remotely piloted vehicles in military, space, and dangerous waste management applications. In this paper focus is given on the main Lossy Compression of SAR Image data. And at the end of this stage the different Quality Evaluation mechanisms are highlighted to measure the quality of resultant image and also to measure the efficiency of the algorithm. These quality measures are useful to check the quality of decompressed image and verify the competitiveness of the algorithm. This work covers the Discrete Cosine Transform (DCT), Block Truncation Coding (BTC) and Gaussian Pyramidal (GP) based compression techniques.

Keywords**—**Lossy Compression, DCT, BTC, GP, SAR image

I. INTRODUCTION

Image processing is a rapidly growing area of computer science. Its growth has been fueled by technological advances in digital imaging, computer processors and mass storage devices. From the beginning of science, visual observation has played a major role. At that time, the only way to document the results of an experiment was by verbal description and manual drawings. The next major step was the invention of photography which enabled results to be documented objectively. Generally, images were only used for documentation, qualitative description, and illustration of the phenomena observed. Fields which traditionally used analog imaging are now switching to digital systems, for their flexibility and affordability. Important examples are medicine, film and video production, photography, remote sensing, and security monitoring. In the modern digital era, digital communication is playing crucial role and visual information has tremendous impact on human lives. It becomes inseparable part of our day-to-day activities. The digital image is one of the media of information. Digital image processing is concerned primarily with extracting useful information from images. Ideally, this is done by computers, with little or no human intervention. It has been suggested that “a picture is worth a thousand words.” This is all the more true in the modern era in which information has become one of the most valued of assets. Recent technology has introduced the paradigm of digital information and its associated benefits and drawbacks. When the time comes to store a photograph digitally, its worth is put to the test [1-4].

A thousand words stored on a digital computer require very little capacity, but a single picture can require much more. A thousand pictures can require a very large amount of storage. While the advancement of computer storage technology continues at a rapid pace, a means for reducing the storage requirements of an image is still needed in most situations. Thus the science of digital image compression has emerged. Current methods of image compression, such as the popular Joint Photographic Experts Group (JPEG) standard, can provide good performance in terms of retaining image quality while reducing storage requirements. But even the popular standards like JPEG have limitations. Research in new and better methods of image compression is ongoing, and recent results suggest that some newer techniques may provide much greater performance than those developed just Seven years ago.

The unprocessed image heavily consumes very important resources of the system. Uncompressed image requires large memory to store the image and large bandwidth to transmit the image data. While the advancement of the computer storage technology continues at the rapid rate the means for reducing the situations. And hence it is highly desirable that the image be processed, so that efficient storage, representation and transmission of it can be worked out. The processes involve one of the important processes called “Image Compression”.

There are two ways for classifying the image compressing techniques: Lossless Compression and Lossy Compression.

Benefits of the Compression:

- It provides a potential cost savings associated with sending less data over network where cost usually based upon its duration.
- It not only reduces storage requirements but also overall execution time.
- It also reduces the probability of transmission errors since fewer bits are transferred.
- It also provides a level of security against illicit monitoring.

II. PREVIOUS WORK

Recent literature on the subject of wavelets has focused mostly on development of the basic theory [11] [12] and methods for application to de-noising and compression. Some authors have already presented brief evaluations of the performance of different frequency domain techniques for SAR image compression [1-6] [13-18]. In this section we summarize Discrete Cosine transform (DCT), Discrete Wavelet Transform (DWT) and Vector Quantization (VQ) based SAR image compression techniques etc.

2.1 DCT based SAR Image Compression:

DCT is an orthogonal transform, which is used widely in optical image compression for its computational efficiency and its energy compaction property. The idea behind orthogonal transforms is to transform the image to new domain where the image is represented ideally by uncorrelated coefficients of which very few carry significant energy and the remaining ones can be quantized to zero. DCT is reported as not appropriate for SAR images due to the presence of speckle noise, high entropy, large dynamic range in DCT domain, important information in high frequency and blocking artifacts in SAR images.

2.2 DWT Based SAR Image Compression:

DWT can be summarized as follows

- DWT allows the allocation of quantization bits to important components both in frequency and time domains.
- Subbands have less dynamic range than the original image.
- Subbands can be used for preview type operations.

2.3 VQ based SAR image compression:

Quantization was one of the first approaches to SAR image compression because of its simplicity. The basic idea is to divide the image into small sub images such that the dynamic range of this sub image is small compared to the whole image and quantize the pixels to a lesser number of bits. In addition to the quantized bits the mean value of the sub image needs to be transmitted. Vector quantization (VQ) is a technique that applies better performance than scalar quantization. VQ based algorithms have been proposed for SAR image compression. The first step in VQ based coding is to produce a codebook. This can be done by using clustering algorithms such as k-means and Linde, Buzo and Gray (LGB) algorithms. A codebook can be produced using empirical data. After dividing the image into sub images each sub image is compared with the codebook and the code for the nearest sub image is transmitted. It is proved that it has higher computational complexity and is not suitable for SAR image compression.

III. EXPERIMENT WORK

Many Transform coding systems are based on the DCT that provide a good compromise between information packing ability and computational complexity, and it's operating on image block wise. For large block size in smooth regions DCT gives better compression [8] [10]. We will take the DCT as our example of transform coding because of its next reason.

- For high-corrupted data the compression rate is obtained by DCT is getting close to that obtained using the option Karhumen-Love Transform (KLT).

- DCT is an orthogonal transform, so if in a matrix form the DCT output is Y=TXT′, then the inverse transform is X= T′YT. The X→Y is named the direct DCT [19].

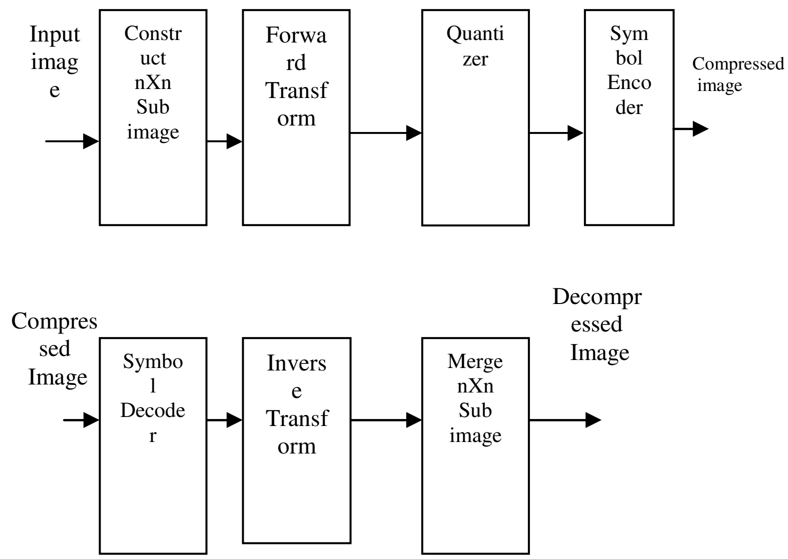

Figure 1: Shows the typical diagram of Transform coding system

An N X N (in pixels) input image is subdivided into sub image of size n X n where n=8 which are then transformed to generate (N/n)2 sub image transform, each of the size of N X N i.e. 8x8. The goal of transformation process is to decorrelate the pixels of each sub image. And quantization stage eliminates coefficients that carry the least information. The encoding process terminates by coding the quantized coefficients [9][10].

In this experiment we have applied DCT in Transform coding for input image. The typical diagram of transform coding system of DCT based compression is shown in figure-1. The compression itself is performed in four sequential steps: 8x8 sub image extraction, DCT computation, quantization, and coder assignment. The first step is to divide the input image into 8x8 sub image. They are subsequently processed from left to right, top to bottom. As each 8X8 block or sub image is processed, its 64 pixels are level shifted by subtracting 2^{m-1}, where 2^m is the number of gray levels in the image, and its 2-D Discrete Cosine Transform (DCT) is computed. The resulting coefficients are then simultaneously normalized, quantized and then coded. The compressed image is applied to

Decoder, De-normalizer, Inverse DCT and 8x8 block merger to get a reconstructed image [20].

Experiments are performed with a radar image acquired by the Spaceborne Imaging Radar-C/X-Band Synthetic Aperture Radar (SIR- C/X-SAR) aboard the space shuttle Endeavour on October 9, 1994. The colors are assigned to different frequencies and polarizations of the radar as follows: Red is L-band vertically transmitted, vertically received; green is the average of L-band vertically transmitted, vertically received and C-band vertically transmitted, vertically received; blue is C-band vertically transmitted, vertically received. The image is located at 19.25 degrees north latitude and 71.34 degrees east longitude and covers an area 20 km by 45 km (12.4 miles by 27.9 miles). We have used 256×256 sc-lval4.jpg image characteristics to demonstrate the performance of the system. Frequency domain techniques like DCT, BTC, and GP are used for decomposing and reconstruction of the SAR image.

CT	SNR	PSNR	RE	CR	MSE	MAE	Compression
DCT	27.318	18.418	99.96	2.799	0.014	0.677	64.27304
BTC	57.231	21.520	99.97	1.035	0.007	0.505	3.42992
GP	18.984	16.991	98.87	2.555	0.019	0.733	60.87269

Table-3.1: Shows the DCT, BTC and GP based Compression of SAR Image

We have given the comparative statistics of the three DCT, BTC and GP techniques. From the Table 3.1 and Table 3.2 we can observe that DCT and GP gives good compression ratio where as BTC gives less compression as compared to DCT and GP. These types of the techniques are not much suitable for the high spectral contents SAR images where frequency are high in the higher resolutions and images are affected by the speckle noise. Since size and dimensions of the SAR images are high, computational complexity increases and more artifacts in the images appears. Since the quality of the images gets blur, analysis and interpretation of the images becomes impossible. Compression in percentage by these techniques are reported (DCT-64.27%, BTC-3.43%, GP-60.87% and DCT – 54.95%,BTC-2.41%,GP-52.26% etc.) in the Table 3.1 and corresponding visual representation is also given in the figures 3.1 (a)-(h).

IV. Conclusion

In this work we have discussed and interpreted DCT, BTC and GP through experimental work, it is concluded that the performance of the compression and decompression generally depends on the image characteristics, type of image, and type of filter, order and level of the decomposition used. For the images tested through wavelet and wavelet packet mostly low frequency contents Discrete Wavelets Transform (DWT) gives good performance. Through this research work it is found that Multiwavelet Techniques are better approach for high compression ratio and to get better performance pertaining to SAR imaging applications. This work can be extended for including major steps like selecting ROI, applying multiwavelet techniques for compression.

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Fig 3.1 (a) sc-lval4.jpg original SAR image [256x256]

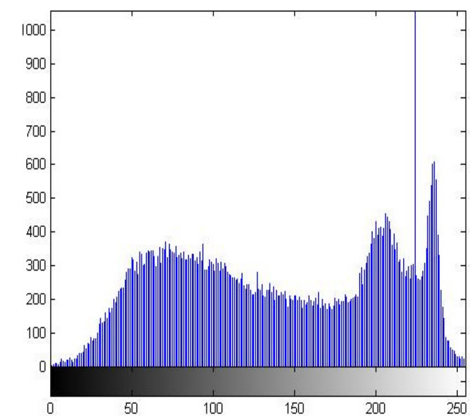

Fig 3.1. (b) Histogram of Fig 3.1 (a)

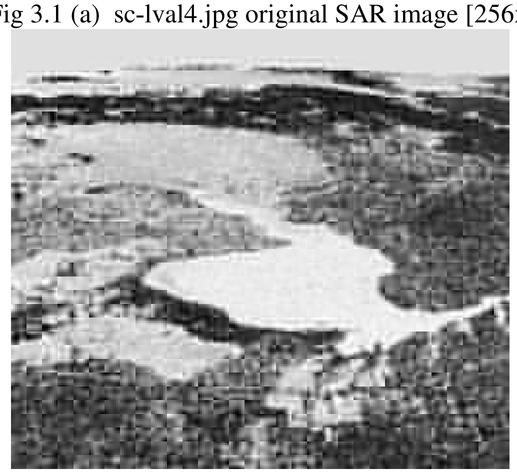

Fig 3.1. (c) Compressed Image using DCT

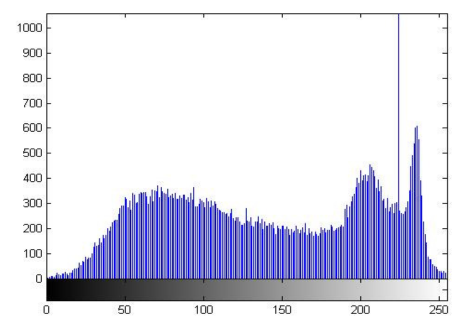

Fig 3.1. (d) Histogram of Fig 3.1. (c)

Fig 3.1. (e) Compressed Image using BTC

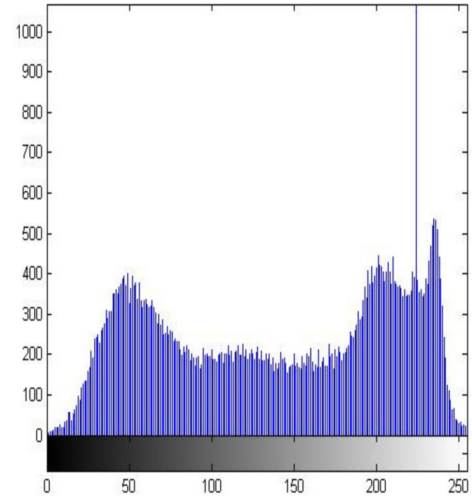

Fig 3.1. (f) Histogram of Fig 3.1. (e)

Fig 3.1. (g) Compressed Image using GP

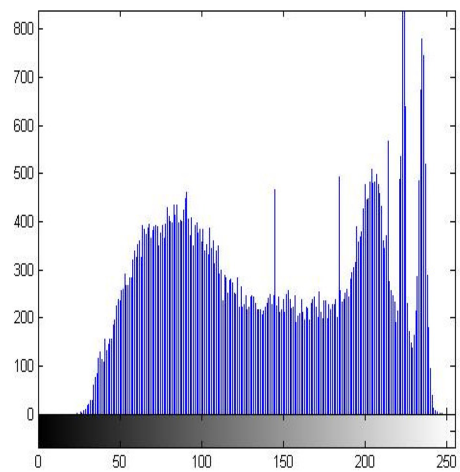

Fig 3.1. (h) Histogram of Fig 3.1. (g)