Review Paper on Image Compression using Wavelet Transform and Compare it with Various Coding Algorithms

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Abstract - In the coming of era the digitized image is an important challenge to deal with the storage and transmission requirements of enormous data, including SAR images. Compression is one of the indispensable techniques to solve this problem. In this paper we compared the improved result of PSNR using wavelet transform along with various type of coding algorithm. The outcome is analysed by variation in BPP (Bit per pixel) for a given image and based on varying BPP we can compare various parameters like peak signal-to-noise ratio and Mean square Error. The directional lifting- wavelet transform along with fast Fourier transform is a very effective approach with low complexity. Using DLWT_FFT along with bit plane coding algorithm we can improve the performance analysis.

Keywords - Synthetic aperture radar(SAR), Directional lifting wavelet transform fast Fourier transform (DLWT_FFT), Set partitioning in hierarchical trees(SPIHT).

I. INTRODUCTION

Synthetic Aperture Radar (SAR) is an active remote sensing system which has applications in geology, agriculture, hydrology, military, ecology, oceanography etc. [1]. SAR systems are mounted on an airplane or satellite, which moves in a particular direction with a particular speed. The movement of the airplane or satellite is used to increase the aperture of the SAR system. The main reason which gives SAR systems such diverse applications is that it has the ability to take images in all weather conditions and darkness. The ease of data handling and flexibility of information transmission have transformed the methods of digital communication in almost every sector .While preparing for such transformation to communication revolution, one has to be prepared with image quality. An example of data transmission of high resolution videos is presented in [2]. The example demonstrates that approximate 30 Megabytes has to be supported. Computing techniques that would considerably reduce the image size that occupies less space and bandwidth for transmission over networks form an active research .Image compression deals with reducing the amount of data required to represent a digital image [2]. Compression and the amount of distortion in the reconstructed image [3]. SAR images have different characteristics as compared to optical images. The differences can be given as follows,

- SAR images are generally larger in size. SAR images normally comprise of 32 bit complex pixels with huge dimensions.
- The entropy of SAR images is greater than that of optical images [4].
- SAR images carry information in low frequency bands as well as high frequency bands. Whilethe optical images are normally low-pass with noise in high frequency regions [4].
- SAR images have a superior dynamic range than optical images.

As a rapidly developing branch of applied mathematics began in the late 1980s, wavelet transform is certainly a milestone in the history of traditional Fourier analysis. Meanwhile, it has become a powerful tool in the realm of digital image compression. The main advantage of wavelet transform over discrete cosine transform (DCT) is that it has both time and frequency localization ability, which result in better performance in image compression. Thus, researchers have paid much attention to wavelet construction and proposed some well-known wavelet bases. Especially, the CDF (Cohen, Daubechies and Feauveau) 5/3 bi-orthogonal wavelet, without standing transform properties, have been wildly used in many areas including the new generation of static image compression standard JPEG2000. The SAR image compression technique has broader scope for compression with varied affliction against like security for defense in noisy channels. The images having amplitude and phase are first-level of complex SAR image systems.

Currently, most compression algorithms of complex SAR image adopt the traditional wavelet transform. However, for the complex SAR images, which are rich in edges and texture, traditional wavelet transform does not show efficient representation. Dong et al. [4] proposed an algorithm which extracted edges of SAR image with wedge let transform and encoded the edges and texture separately. Li et al. [5] used 2-D oriented wavelet transform for remote sensing compression. The SAR images used in [4], [5] are not complex SAR images. The spatial-domain directional wavelet, such as directional lifting wavelet transform (DLWT), employs direction prediction for wavelet decomposition, which adapts the wavelet transform direction to the image edges. DLWT [6] – [8] integrates spatial direction prediction into the wavelet transform lifting framework, provides an efficient. Mohammed Hamzah Abed et al. use a modified version of SPIHT for two dimensional signals which is lossless [9]. G.Chenchu Krishnaiah et al. performs 9/7 and 5/3 wavelets on photographic images (monochrome and color) and estimated Peak Signal to Noise Ratio (PSNR) [10]. J. Maly et al. Proposes an implementation of discrete-time wavelet transform based image codec using Set Partitioning in Hierarchical Trees (SPIHT) coding in the MATLAB environment. The results show that the CDF 5/3 perform best results among all tested wavelet families [11].

In our work we have selected SAR image because it has large scope for compression and this image has varied affliction like a security system for defence, for natural climatic etc. The phase information is crucial for sensitive applications like interferometry and moving target detection. Hence, the normal image compression is reasonably different with SAR image compression as this scheme seeks high phase information accuracy and amplitude fidelity.

The SAR image is passed through Fast Fourier Transform (FFT) that generates complex signals in real and imaginary form. Both frequencies are shifted to positive side. To balance the distortion quad-tree segmentation is used. Further the image is decomposed in to binary image using bit plane encoding. The image is processed with CDF 5/3 tap filters and Hilbert transform is done and the image is then passed through Inverse Discreet Wavelet transform. The proposed two coding schemes show significant performance gain not only in amplitude peak signal-to-noise ratio (PSNR) but also in mean square error (MSE). The bit-plane coding is based on decomposing a multilevel (monochrome or color) image into a series of binary images and compressing each binary image by one of several well-known binary compression methods. The intensities of an m-bit monochrome image can be represented in the form of base-2 polynomial:

$$a_{m-1}2^{m-1} + a_{m-2}2^{m-2} + \ldots\ldots\ldots\ldots + a_1 2^1 + a_0 2^0 \quad (1)$$

Therefore, to decompose an image into a set of binary images we need to separate m coefficients of the polynomial into m 1-bit planes. The lowest order bit-plane (corresponds to the least significant bit) is generated by a_0 bits of each pixel, while the highest order bit-plane contains the m-1 bits. PSNR is the ratio between the greatest likely power of a signal and the power of corrupting noise that affects the fidelity of its representation. As various signals have a very extensive dynamic range, PSNR is generally conveyed in terms of the logarithmic decibel scale. The PSNR is most commonly used as a measure of quality of reconstruction by lossy compression code (e.g., for image compression).

$$PSNR = 10*\log_{10}((\text{dynamics of image})^2)/ MSE \quad (2)$$

The MSE of an estimator is one of various ways to measure the modification between values created by an estimator and the true values of the quantity being projected. MSE calculates the middling of the squares of the "errors." The error is the quantity by which the value created by the estimator varies from the quantity to be projected. The alteration happen showing to arbitrariness or owing to the estimator doesn't account for data that could yield a more precise estimate.

SPIHT is a wavelet based image compression coder that produce various advantages such as good image quality with a high PSNR, fast encoding and decoding speed, a fully progressive bit stream, used for lossless compression, ability to stop at any target bit rate. It is a very efficient image compression algorithm that is based on the idea of coding groups of wavelet coefficients as zero trees.

II. WAVELET ANALYSIS FOR IMAGE COMPRESSION

Wavelet analysis allows the use of long time interval where more precise low frequency information is required and shorter regions where high frequency information. Wavelet means a wavelet is a waveform of effectively limited duration that has an average value of zero. The wavelet transform (WT), in general, produces floating point coefficients. Although these coefficients are used to reconstruction original image perfectly in theory, the use of finite precision arithmetic and quantization results in a lossy scheme. The lifting scheme based wavelet Transform can be implemented as shown in fig.1 for reducing computational complexity. Only the decomposition part of WT is depicted inFig.1 because the reconstruction process is just the reverse version of Fig.1. The lifting-based WT consists of splitting, lifting, and scaling modules and the WT is treated as prediction-error decomposition. It provides a complete spatial interpretation of WT.

Splitting

In this stage the input signal is divided into two disjoint sets the odd (x[2n+1]) and the even samples (x[2n]).

Lifting

In this module, the prediction operation P is used to estimate X from $X_e(n)$ and results in an error signal d(n). Then we update d(n) by applying it to the update operation U, and the resulting signal is combined with $X_e(n)$ to s(n) estimate, which represents the smooth part of the original signal.

Scaling

A normalization factor is applied to d(n) and s(n) respectively. In the even-indexed part s(n) is multiplied by a normalization factor K_e to produce the wavelet sub-band X_{L1}. Similarly in the odd-index part the error signal d(n) is multiplied by K_o to obtain the wavelet sub-band X_{H1}. The output result is X_{L1} and X_{H1} by using the lifting-based WT are the same as those of using the convolution approach for the same input.

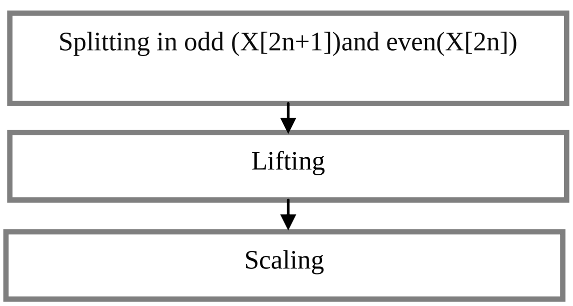

Fig 1: Flow of wavelet transforms

III. PREVIOUS WORK

Some papers have surveyed through this work, after review these papers aimed methodology is proposed:

Sanjay H. Dabhole et al analyse adaptive lifting based wavelet methods for the purpose of image compression. The initial image is changed by employing adaptive lifting based CDF 9/7 wavelet transform and conventional CDF 9/7 then it is compressed by applying Set Partitioning In Hierarchical Tree procedure (SPIHT) then the functionality was weighed against the popular traditional CDF9/7 wavelet transform. The functionality metric Peak Signal to Noise Ratio for the reconstructed image was calculated. The suggested adaptive lifting procedure give healthier performance than conventional CDF9/7 wavelet, the most well-known wavelet transforms. Lifting permits us to join adaptive and nonlinear operators into the transform. The projected approaches efficiently characterize the appear and edges, promising for image compression. The suggested adaptive approaches reduce edge and give better PSNR of 4.69 to 6.09 dB than the conventional CDF 9/7 for edge dominated 2D images [14].

Vimal Kumar et al suggested a new wavelet bi-orthogonal filter coefficients for wavelet decomposition and reconstruction of image for better image compression, when the image is compressed with the help of these filter coefficients in the DWT-SPIHT schema then it performs well as compared to the DWT-SPIHT scheme with wavelet 9/7 filter and wavelet 5/3 filter. The analytical outcome obtained using these filter coefficient display that the reconstructed image has better PSNR and low MSE than wavelet 9/7 filter and wavelet 5/3 filter [15].

Walaa M. Abd-elhafier et al describes an efficient lifting based hybrid image coding (LB-HIC) scheme. The suggested framework is based on using the lifting to transform (LT) in conjunction with the discrete cosine transform (DCT) to provide coding performance superior to the popular image coders. The suggested process uses a combination of the DCT and Set partitioning in hierarchical tree (SPIHT) coding. The sub-band image data in the lifting domain are modified based on the DCT and the object classification of the coefficient in the lower frequency sub band (LL). The modification process provides a new sub band image data containing almost the same information of the original one, but having the small values of the lifting coefficients. Simulation of the proposed method show that, with a modest addition in the computational intricacy of the coding procedure, the PSNR effectiveness of the suggested algorithm is quite a bit higher than that of the SPIHT test coder and some of well-known image coding methods[16].

Xingsong Hou et al proposed directional lifting wavelet transform (DLWT) for compression of complex synthetic aperture radar (SAR) images. As real-part and imaginary-part of the complex SAR image are rich in edges, two complex SAR image coding algorithms using DLWT, i.e. DLWT_IQ and DLWT_FFT are proposed. DLWT_IQ separately applies DLWT and a bit plane encoding on the real part and imaginary-part. DLWT_FFT applies DLWT and a bit plane encoding of the real image converted from complex SAR image with fast Fourier transform (FFT). Compared with the coding algorithms using discrete wavelet translation (DWT), DLWT_IQ and DLWT_FFT perform better amplitude peak signal to noise ratio (PSNR) and mean phase error (MPE) than coding algorithm using DWT. Through comparison of the two algorithms using DLWT, DLWT_FFT's coding performance is better. In addition, DLWT_FFT also shows superior amplitude and phase fidelity to the frequency-domain algorithm [17].

IV. PROPOSED METHODOLOGY

The initial step of image compression is the selection of image that is passed through 1-D Fast Fourier Transform (FFT). The negative frequency band is shifted to positive frequency band that increases the original bandwidth of signal to 200% and original frequency signal is focused on positive frequency band. Second, do 1-D IFFT transform and get a complex signal with data volume doubled; lastly, characterize the complex signal with its real part as the imaginary part and the real part of the complex signal fulfil the Hilbert transform. The spectrum movement is corresponding to supplement zeros on the negative side of the frequency signal and creates the bandwidth doubled; so, the complex signal which is the resultant signal of the inverse FFT transform is corresponding to interpolate the complex SAR image by every two pixels on the dimension of transform.

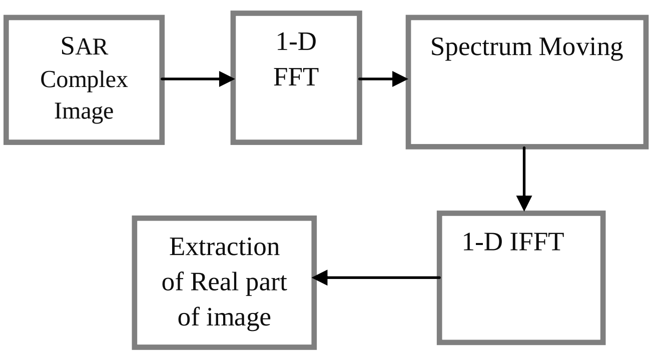

Fig 2: block diagram of FFT

The Cohen-Daubechies-Feauveau (CDF) 5/3 bi-orthogonal wavelet is a simple wavelet that has two sets of scaling and wavelet functions for analysis and synthesis, hence bi-orthogonality. The CDF 5/3 wavelet has a 5-tap low-pass analysis filter h(z) and 3-tap high-pass analysis filter g(z), hence 5/3. The CDF 5/3 also has a 3-tap low-pass synthesis filter h(z)' and 5-tap high-pass synthesis filter g(z)'. It is apparent that two lift steps are required, one predict and one update step, to perform the CDF 5/3 DWT.

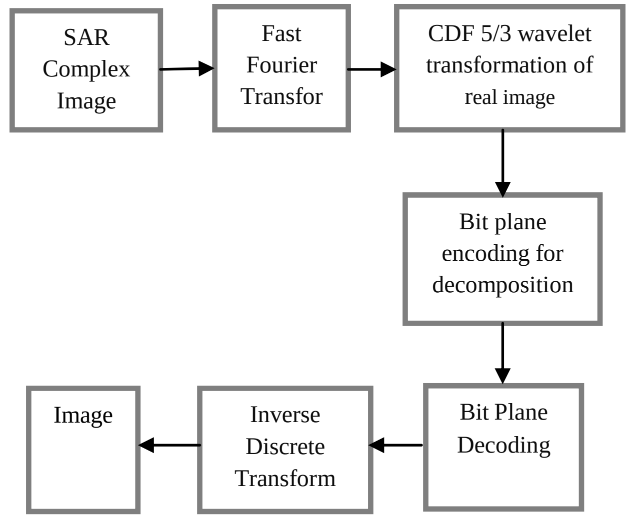

Fig3: Flowchart of proposed methodology

V. COMPARISON OF CODING PERFORMANCE IN PSNR (db)

In this section we take an image and comparison of performance analysis is listed in the table below for variation in bit per pixel.

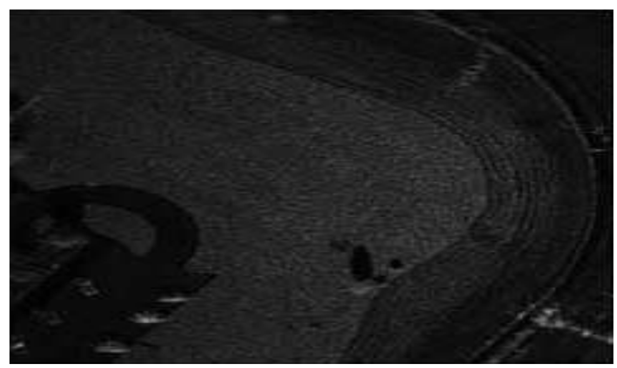

Fig4: Real part of SAR image

Table 1.For figure 4

1.0BPP				
Fig 4	DLWT_FFT	DWT_FFT	DLWT	SPIHT
	71.20	70.15	70.88	70.83

Table2.For figure4

3.0BPP				
Fig 4	DLWT_FFT	DWT_FFT	DLWT	SPIHT
	81.84	81.14	81.66	81.11

Table3. For figure5

5.0BPP				
Fig 4	DLWT_FFT	DWT_FFT	DLWT	SPIHT
	93.97	92.44	93.73	91.73

VI. CONCLUSION

The objective of this paper is undoubtedly the improvement of images quality after the compression. In literature survey paper there are various image compression techniques used along with different kind of algorithm. In our work we would use the CDF Lifting based wavelet transform, coupled with the Bit plane coding. After several applications and observations we will found that this algorithm gives better performance than other compression algorithm.

VII. FUTURE SCOPES

The future scope of the presented work can be summarized as following.

- The techniques can be extended for video compression.
- The techniques can be extended for any other image processing applications for better results.

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