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Image Compression using Modified Discrete Wavelet Transform with spatial domain High Boost Filter

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ABSTRACT: Multimedia technology growing very widely and this technology are extensively used for computer graphics application. This application generates various high quality images whose size is very large. The storage of such images is critical task which requires huge storage media and it also create problem in uploading and downloading these data over internet. That is why image compression becomes very essential these days. For compressing the image without losing the requisite information and disturbing the quality of image so many techniques has been developed such as wavelet transformation and curvelet transformation etc. but these compression techniques has their personal constraint. In this paper, we use modified wavelet transform with high boost filter (WT-HBF) in spatial domain. The experimental results of our methodology are much more efficient in reducing the size of image than the existing techniques. The comparative analysis of this method is perform using different performance measuring parameter such as MSE, RMSE, PSNR, and SNR etc.

Keywords: Multimedia, Wavelet, MSE, PSNR, SNR, RMSE, Compression

I. INTRODUCTION

Due to the swift progress in digital technology in the field of electronics, the capturing and storing of image data becomes critical issues now a days because the size of images is very large which requires more storage space to store and also requires more time in uploading or downloading the image data. In image processing, compression is one of the techniques by which the size of image can reduce and also increases the transmission rate of image data. There are so many techniques have been developed to compress the images but during the compression process, these technologies diminish the quality and also add some noise with the image. The compression can be achieved by the removal of these basic image data such as coding redundancy, inter pixel redundancy and psycho visual redundancy. The spatial and spectral redundancies are present because certain spatial and spectral patterns between the pixels and the color components are common to each other, whereas the psychovisual redundancy originates from the fact that the human eye is insensitive to certain spatial frequencies [1]. The image compression techniques are classified into two categories: Lossless compression and lossy compression. Several standards such as JPEG200, MPEG-2/4 recommend use of Discrete Wavelet Transforms (DWT) [2] for image transformation which leads to compression with when encoded. Wavelets are a mathematical tool for hierarchically decomposing functions in multiple hierarchical sub bands with time scale resolutions. Image compression using Wavelet Transforms is a powerful method that is preferred by scientists to get the compressed images at higher compression ratios with higher PSNR values. It is a popular transform used for some of the image compression standards in lossy compression methods. Unrelated the discrete cosine transforms, the wavelet transform is not Fourier-based and consequently wavelets do a superior job of handling discontinuities in data. The Discrete Wavelet Transform (DWT) is a proficient and valuable tool for signal and image processing applications and will be adopted in many emerging standards, starting with the new compression standard JPEG2000.

The compression process of JPEG image data is shown in figure 1.

The arrangement of the remaining part of the paper is done as follows: Section II describes literature of previously work done for compressing the image. Section III gives whole description of our proposed methodology. Experimental results and its analysis is described in section IV and last section presents overall conclusion of the paper.

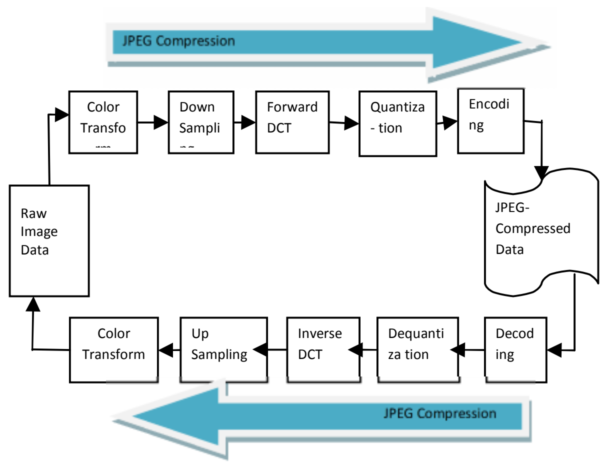

Fig. 1. Compression process of JPEG image data.

II. RELATED WORK

Reduction of storage space and enhancement in transmission rate of digital image data is the major requirement in this era and lots of work has been done in this area of image processing. In this section of the paper, we present the literature study of different approaches which is described below:

In [3] offered the design and implementation of distributed arithmetic (DA) constructions of three-dimensional (3-D) Discrete Wavelet Transform (DWT) with fusion technique for medical image compression. Due to the separability characteristic of the multi-dimensional Haar and Daubechies, the projected construction has been implemented using a cascade of three N-point one-dimensional (1-D) Haar/ Daubechies and two transpose memories for a 3-D volume of N×N×N, apposite for 3-D medical imaging applications. The deisghns were synthesized by means of VHDL and G-code and implemented on field programmable gate array (FPGA) single board RIO (sbRIO-9632) with Spartan-3 (XC3S2000). In [4] presented the exercise of Wavelet Based Image compression algorithm based on Embedded Zerotree Wavelet (EZW). They had obtained a bit stream with increasing accuracy from ezw algorithm because of basing on progressive encoding to compress an image into. All the numerical results were done by using matlab coding and the numerical analysis of this algorithm is carried out by sizing Peak Signal to Noise Ratio (PSNR) and Compression Ratio (CR) for standard Lena Image. Experimental results beam that the method is fast, robust and efficient enough to implement it in still and complex images with significant image compression. In [5] described the hybrid approach to image compression is discussed. A compression method using neural-network and discrete wavelet transform is presented here. This scheme combines the high compression ratio of Self organizing map neural network with the good recreation property of discrete wavelet transform (DWT). The performance of proposed method is compared with the available SOFM NN based compression technique considering standard images. In [6] focused on offering a non-linear image compression system that compresses images mutually radically and angularly. Wavelet-based Contour-let Transformation (WBCT) has the possibility to estimate the natural images encompassing contours and oscillatory patterns. In addition to this transformation scalar quantization system is used to abolish the redundancies in the images. In conclusion, this technique used modified set partitioning in Hierarchical Trees (MSPIHT) for the proficient encoding process. The experimental consequences of wavelet-based contour-let transformation with scalar quantization and MSPIHT are superior when compared with existing transformations techniques. In [7] proposed a fresh image compression technique which integrates Support Vector Machine (SVM) regression with curvelet transform. Initially, the original image was decomposed into curve let coefficients through fast discrete curvelet transform. Then, for lossy compression and entropy encoding, various scales of quantized curve let coefficients were chosen. For instance, the lowest sub-band is encoded by Differential Pulse Code Modulation (DPCM) for constituting the majority of image energy. The fmer scale sub-bands are compressed by SVM regression, wherein the curvelet coefficients are approximated through a fewer support vectors and weights. Certain finer scale sub-bands are removed directly as they contains less energy and have small obvious consequence on the image quality. The performance of this approach is better when compared with the performance of the wavelet based image compression techniques. In [8] proposed a curve let transform based method had revealed capable outcomes over wavelet transform for 2D signals. Wavelets are very appropriate to point singularities but have drawbacks with orientation selectivity, and thus, do not denote two-dimensional singularities (e.g. smooth curves) efficiently. This approach utilizes the curvelet transform for image compression, with significant approximation attributes for smooth 2D functions. Curvelet enhances wavelet by integrating a directional component. The curve let transform identifies a direct discrete-space construction and is thus computationally significant. The author partitioned 2D spectrum into slices through iterated tree structured filter bank. Various scales of quantized curvelet coefficients were chosen for lossy compression and entropy encoding. The performance of the approach is compared with wavelet based compression techniques with the standard images such as Lena, Barbara, etc. Curvelet transform has resulted in considerable result for natural images. This approach supplies precise reconstruction of the image with low computational complexity.

III. DISCRETE WAVELET TRANSFORM WITH HIGH BOOST FILTER

The discrete wavelet transform is widely used technique to reduce the size image data. The overview of discrete wavelet transform is described below:

A. Discrete Wavelet Transform

In the DWT, an image signal or image can be scrutinized by passing it through an investigation filter bank followed by decimation operation. The analysis bank consists of a LPF and HPF at each decomposition stage. When the signal passes through these filters, it splits into two bands. The LPF, which corresponds to an average operation, taken out the coarse information of the signal. The HPF, which communicates to a differencing operation, extorts the specific information of the signal. The output of filtering operation is then decimated by two. A 2-D transform is accomplished by performing two separate 1-D transforms [10]. First, the image is filtered using LPF along the row and decimated by two for getting the low frequency components of row. However, because the LPF is a half band filter, the output data restrains frequencies only in the first half of the unusual frequency range. Accordingly, by Shannon's sampling theorem, they can be sub-sampled or decimated by two, so that the output data restrains only half the original number of samples. Now, the HPF filter is applied for the identical row of data, and simultaneously the high pass components are separated, and placed by the side of the low pass components. This course of action is done for the all rows. After that, the filtering is done for sub-image to each column and decimated by two. The resulting is 2-D array of coefficients of four bands. This operation splits the image into four bands, namely LL, LH, HL and HH respectively as shown in Fig. 2.

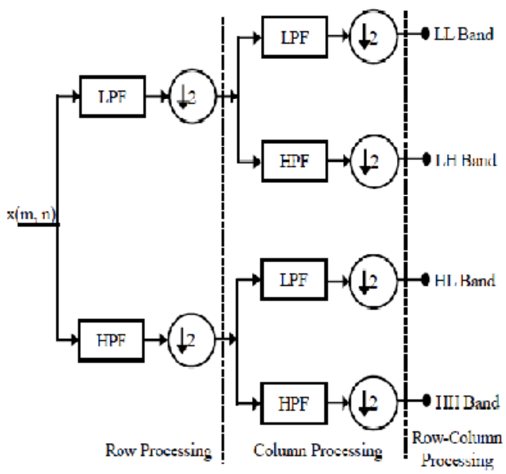

Fig. 2. Wavelet based decomposition.

Although Image compression algorithms based on DWT provide high coding efficiency for natural (smooth) images, the standard DWT has three major disadvantages that weaken its application. These disadvantages such as lack of shift invariance, deprived directional selectivity and absence of phase information [10].

B. High Boost Filter

High -boost Filtering: A high - boost filter is also known as a high- frequency emphasis filter. A high-boost filter is used to preserve a few of the low-frequency components to aid in the interpretation of an image. In high - boost filtering input image h (m, n) is multiplied by an amplification factor A before subtracting the low-pass image. Therefore, the high-boost filter expression becomes

$$High\ Boost = A \times h(p,q) - low\ pass \ldots\ldots\ldots\ldots\ldots (1)$$

Adding and subtracting 1 with the gain factor, we get

$$High\ Boost = (A-1) \times h(p,q) + h(p,q) - low\ pass (2)$$

IV. PROPOSED METHODOLOGY

In this section, describes our proposed method of research for image compression.

A. Spatial Redundancy

The majority of the image restrains correlated pixels. If the neighboring pixels are spatially correlated to each other, after that it is known as spatial redundancy. In this thesis work, the spatial redundancy has been taken into contemplation and data compression algorithm is analyzed by dipping the spatial redundancy.

Multilayer Wavelet and Dual Tree Complex wavelet Transform (ML-DTCWT). The proposed methodology agrees with the amalgamation of multilayer wavelet and dual tree complex wavelet transform for image compression. The image compression method proposed here is pertinent to every standard grayscale digital images where high exactitude reconstructed image is obligatory. In the proposed methodology, for image brightness and contrast has been enhanced and preserved by means of foremost brightness level investigation and adaptive intensity transformation. More explicitly this approach primary executes the DWT to decompose the input image into a set of band-limited components, called HH, HL, LH, and LL sub bands. Since the LL sub band has the brightness information, the log-average luminance is computed in the LL sub band for calculating the foremost brightness level of the input image and filter also functional. The LL sub band is decomposed into low, middle, and high-concentration layers according to the foremost brightness level.

The adaptive intensity transfer function is calculated in three decomposed layers using the dominant brightness level, the knee transfer function [9].

Huffman Coding. The huffman coding is an entropy encoding algorithm which is used for lossless data compression. It consents to the exercise of a changeable-length code table for encoding a source symbol (for example a character in a file) where the changeable-length code table has been derived in a painstaking way based on the anticipated probability of occurrence for each probable value of the source symbol. It utilizes a explicit method for preferring the demonstration for every symbol, resulting in a prefix code that articulates the most frequent start symbols using lesser strings of bits than are used for not as much of regular source symbols. The Huffman algorithm is based on statistical coding, which indicates that the probability of a symbol has an express bearing on the length of its demonstration.

After completing the layered process CWT apply check whether any information lost or not, if any information lost then revert it back otherwise process it for next iteration. The overall followed steps are:

1. Take a standard digital image and stored into variable (I).
2. Apply DWT into taken image.
3. Analyze Dominant brightness level on the basis of the LL band of DWT process.
4. Start decompositions on the basis of dominant brightness levels in to LL, LH, HL, HH sub bands.
5. Applying adaptive intensity transfer function into different intensity levels of the decomposed image and then smoothing the sub bands.
6. The smoothened image goes to the DTCWT.
7. Modify wavelet coefficients using and applying Kingsbury Q-filters.
8. Apply Huffman encoding to compress the modified coefficients images.
9. Stores the compressed image.
10. Now reconstruct the image using reverse process called Huffman decoding.
11. Apply high boost filter to enhance quality of reconstructed image
12. Inverse function of dual tree complex wavelet transforms ($DTCWT^{-1}$).
13. Store reconstructed image is in separate variable (out_I).
14. Calculate MSE (I, out_I), RMSE (sqrt(MSE)), PSNR (I, out_I), SNR(I_out, I).

Used comparison parameter is PSNR, MSE, RMSE and SNR of the image with a standard formula.

Mean Squared Error (MSE)

$$MSE = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}(A_{ij} - B_{ij})^2 \qquad \text{... (3)}$$

Peak Signal to Noise Ratio (PSNR)

$$PSNR = 10 \times \log_{10}\left(\frac{peak^2}{MSE}\right) \qquad \text{... (4)}$$

Root Mean Squared Error

$$RMSE = \sqrt{MSE} \qquad \text{... (5)}$$

V. EXPERIMENTAL RESULTS

In this section, the performance of our proposed method of image compression using modified SVM in spatial domain with high boost filter is deliberated. Experimental setting: computer frequency of 3.2 GHZ with 4 GB memory, Software Environment MATLAB 2012A. In the experiment, we compared the quality of reconstruction image. Simulation results are tested on five trained standard images such as Lena, Barbra, Baboon, cameraman and boat. Below is the compression of the tested images outcomes: each figure containing the four parallel processed output images where first image is an input original image therefore DCT, DWT and proposed DWT-HBF resulted images are shown and the comparative analysis of our method is done using well known performance measuring parameter such as MSE, RMSE, SNR and PSNR which are described below [12].

Mean Square Error (MSE): MSE is the measure of error between the original image and the compressed image. Mean Square Error is the cumulative squared error between the compressed image and the original image

$$MSE = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}[I(x,y) - I'(x,y)]^2$$

Peak Signal to Noise Ratio (PSNR): PSNR is the ratio of maximum power of the signal and the power of unnecessary distorting noise. Now the signal is the original image and the noise is the error in reconstruction. For a better compression the PSNR must be high.

$$PSNR = 20 \times \log_{10}\left[\frac{255}{\sqrt{MSE}}\right]$$

Fig. 3(a). DCT, DWT and DWT-HBF for Jaya own image.

Fig. 3(b). DCT, DWT and DWT-HBF for Lena image.

The above figure 3(a), 3(b) and similarly tested for Barbra, Boat, and Cameraman images in which the compression technique is applied. The performance evaluation result of our proposed method is tabulated by comparing it DCT and DWT. The mean square error (MSE) and root mean square error (RMSE) of our approach is much better than existing techniques which are tabulated in table 1, table 2 and result of this parameter is shown in figure 4 & 5.

Table 1: MSE result for standard input image.

MSE comparison of DCT, DWT, DWT-HBF			
Method/Image	**DCT**	**DWT**	**DWT-HBF**
Lena	13.1477	7.0029	4.20142
Barbara	3.08036	1.4807	6.66621
Boat	11.6569	3.72092	1.23256
Cameraman	13.7442	3.13988	0.287481
Jaya-own	3.79704	1.5134	0.635119

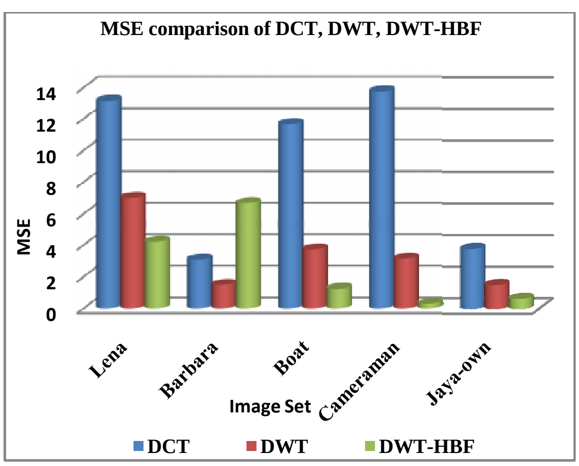

Fig. 4. Shows MSE comparison of DCT, DWT, DWT-HBF.

Table 2: RMSE result of standard input image.

RMSE comparison of DCT, DWT, DWT-HBF			
Method/Image	**DCT**	**DWT**	**DWT-HBF**
Lena	3.62598	2.6463	2.04974
Barbara	1.75509	1.21684	2.5819
Boat	3.41422	1.92897	1.11021
Cameraman	3.70731	1.77197	0.536173
Jaya-own	1.9486	1.2302	0.796944

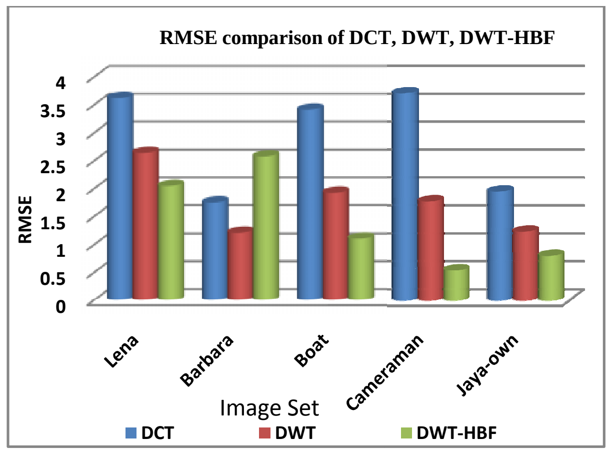

Fig. 5. Shows RMSE comparison of DCT, DWT, DWT-HBF.

The peak signal to noise ratio (PSNR) and signal to noise ratio (SNR) of our approach gives better than existing techniques illustrated in table 3, table 4 and result of this parameter is shown in figure 6 & 7.

Table 3: PSNR result for standard input image.

PSNR comparison of DCT, DWT, DWT-HBF			
Method/Image	**DCT**	**DWT**	**DWT-HBF**
Lena	33.8763	40.8251	47.5413
Barbara	32.3671	39.2765	46.4576
Boat	34.0896	42.1328	50.4202
Cameraman	33.7976	42.4839	53.8375
Jaya-own	36.0779	43.9933	51.9767

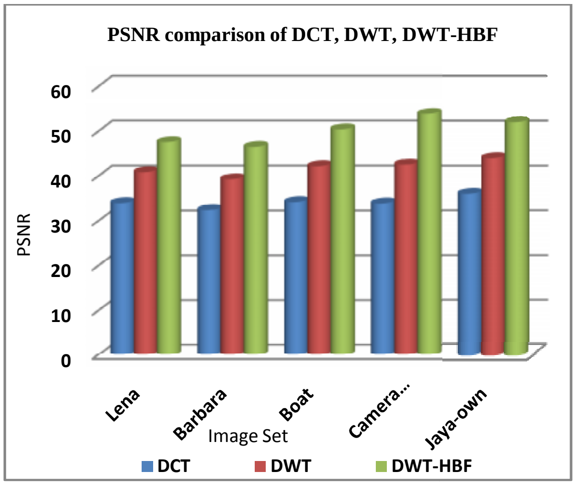

Fig. 6. Shows PSNR comparison of DCT, DWT, DWT-HBF.

Table 4: SNR result of standard input image.

SNR comparison of DCT, DWT, DWT-HBF			
Method/Image	**DCT**	**DWT**	**DWT-HBF**
Lena	3.5871	3.83238	3.63547
Barbara	2.82279	3.02933	3.03052
Boat	3.77642	4.69028	5.57361
Cameraman	3.56532	4.84674	8.50309
Jaya-own	5.76115	6.90238	7.92125

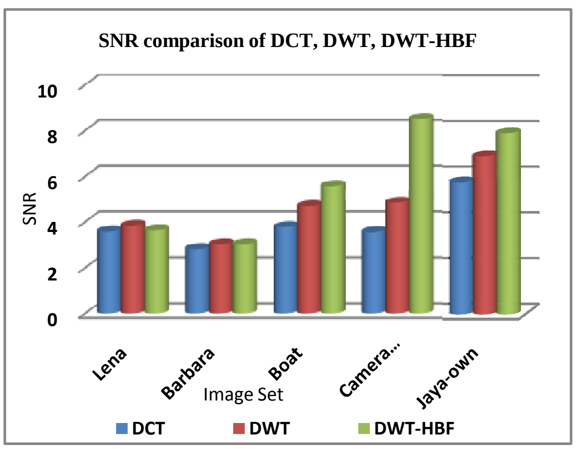

Fig. 7. Shows SNR comparison of DCT, DWT, DWT-HBF.

VI. CONCLUSION

The quality of digital image data is very good but such kind of image requires more memory space due to this the storage cost is very high so to reduce the storage cost and transmission rate of these data is very essential and for this so many techniques has been evolved. In this paper, we propose a novel approach for image compression in which uses DWT in spatial domain data which efficiently compress the size but it includes noise in the image so to eliminate the noise or sharpening the image filtering technique is uses. The high boost filter reduces it very effectively than the other existing approach. In last our proposed approach gives more improved result than the DCT and DWT. The proposed methodology is tested on standard input image of Lena, Barbara, Boat, Cameraman and Jaya etc. In future work, need to compare this approach on other performance metrics except PSNR, MSE, SNR and RMSE and also recues the number of iteration successfully.

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