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Heterogeneous Approach of Quality Preserving Image Compression Technique Using Wavelet and Contourlet Based Interpolation

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Abstract. In this paper heterogeneous approach of feature preserving lousy image compression using wavelet and Contourlet based interpolation techniques are incorporated to elevate the compression ratio and PSNR at the Receiver. In this approach edges are transmitted to the receiver as header information to preserve the high frequency details of the image. An edge image is obtained from the original image using basic wavelet transform. Then the original image is domain transformed using wavelet transform which has multi-resolution capability at 'n' number of orientations and then wavelet coefficients are encoded using zero tree encoder. The compressed image is reconstructed at the receiver using Contourlet based interpolation technique to extract the loss of pixel values while processing. The valuable parameter such as Compression Factor and Peak Signal to Noise Ratio are calculated. The performance table is provided in comparison of the proposed method with the existing method of edge preserving image compression indicating the superior performance of the proposed technique in comparison with existing technique.

Keywords: Compression Factor, Edges, Adaptive Wavelet Transform, Edge detectors, Contourlet Transform.

1. Introduction

Graphics and images are the core part of the multimedia systems, which has an engrossing appeal and that's why it attracts more and more users. But due to expensive bandwidth, time consuming downloads and processing of images makes image compression necessary to crunch an image into small size. The higher compression ratios have been achieved using *a lossy technique that removes* visual information that is not perceived by the human eye i.e. loss of fidelity occurs in lossy image compression.

However, the high energy or frequency components of the image correspond to the edge information – the use of transform-based coding techniques [2] effectively results in the blurring of edges and other high-frequency contents of the image, which reduces the picture quality. Furthermore, at high compression ratios, the distortion rate increases significantly as well, resulting in patchy or blocky images. In contrast the edge preserving techniques preserves the high frequency components which increases the picture quality.

The reminder of this paper is structured as follows. Initially the related works are explained in section 2, the proposed system architecture is explained in system3, the various components of the proposed system is explained with examples in sub sections of section4,Proposed algorithm is explained in section5,perfomance analysis and results of the proposed method are discussed in section6 and then concluded with future scopes and applications.

2. Related Works

In general the digital images are represented using shapes edges contours etc. that gives important information about the images [3].This allows the images to be compressed at low bit rates and thereby enhancing the quality of the images. Preserving certain features of the images became essential in some applications such as medical, textile etc. where there is restriction in usage of original image [4].

Using DWT the de-correlation of images can be done and hence representing the images with less number of coefficients than required [5].The main drawback is that DWT cant track the edges continuously hence some post processing techniques is required to maintain the quality of the image which is proposed in this paper. The alternate way of edge preserved image compression techniques is proposed in [6]. In this paper edge information is extracted first and coded separately then the image is coded separately. The main drawback is that the image to be coded requires side information. The problem in the previous paper [7] is solved by using an alternative method [8], in which the Wavelet Transform and iterative least square regularization are used. Here the edge information is used as a priori-knowledge for image reconstruction and the spatial information obtained using wavelet transform is used for restoration at the reconstruction environment, which does not interpolate the distorted information. Finally Filter banks [9], [10] are used to preserve the images from scale to scale at various directions.

All the related works concentrates in either one of the inferences and lags behind in some of the characteristics. Effectively there is a tradeoff between compression ratio and picture quality in all the methods, hence in this proposed paper an effective approach is used to handle both the compression ratio and PSNR by using novel technique.

3. Proposed System

A novel heterogeneous compression system has been introduced (see fig1) to increase the compression ratio along with image quality by feature preserving. In traditional compression systems the high frequency components are lost due to the encoding scheme. But in some applications namely in Medical applications, Forensic applications etc. high frequency components are important for diagonisation. The proposed system provides a way for preserving high frequency components such as edges in crunched representation to improve the quality of the image.

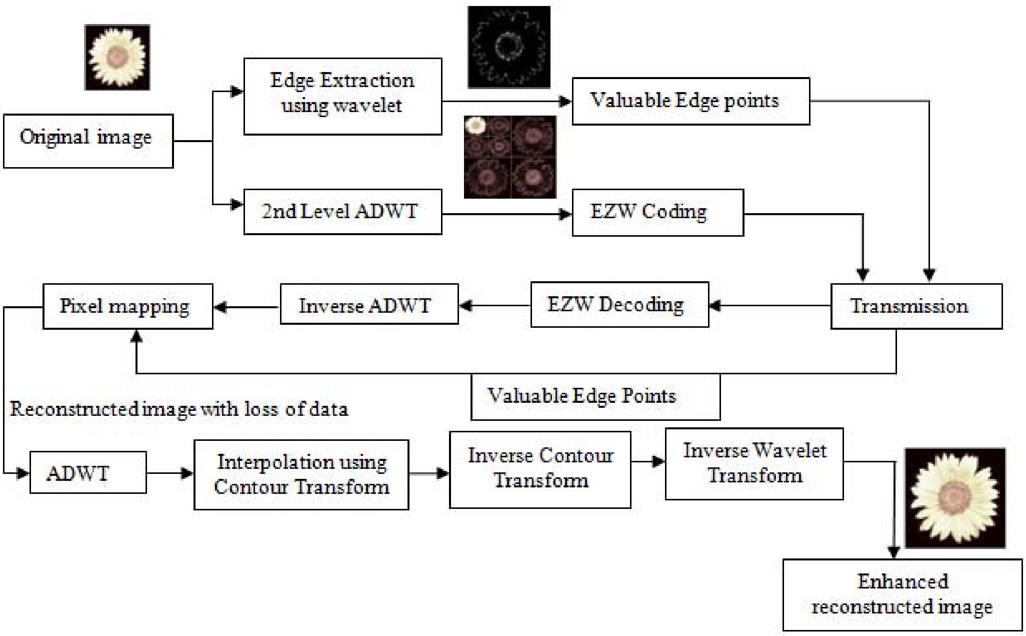

Fig. 1: Block Diagram of Proposed Compression System.

4. Components of the Proposed System

4.1. Wavelet transform and ezw encoder

In wavelet based compression systems, the entire image is wavelet transformed instead of block transformation as in DCT, which introduces Blocking artifacts. In case of wavelet transform the error is distributed over the entire image [11]-[13]. The DWT offers high spatial-frequency resolution at high frequencies and high frequency resolution at low frequencies, which preserves the characteristics of the HVS.

DWT of the 2D image can be computed from 1D wavelet transform. The scaling and wavelet function of a 2D image can be obtained by multiplying two 1D wavelet functions. The scaling function of the 2D wavelet transform can be obtained from the following equation

$$\Phi(x,y) = \Phi(x)\Phi(y) \quad (1)$$

For the 2D wavelet function, there exist three different scaling functions namely horizontal, vertical and diagonal function as in below equations

$$\psi^{(H)}(x,y) = \Phi(x)\psi(y) \quad (2)$$

$$\psi^{(V)}(x,y) = \Phi(y)\psi(x) \quad (3)$$

$$\psi^{(D)}(x,y) = \psi(x)\psi(y) \quad (4)$$

The output of the wavelet transform is the wavelet tree, which consists of significant and non-significant coefficients. The significant and non significant coefficients has to be coded in a hierarchical order, hence an Embedded zero tree wavelet encoder [14] is used to scan the coefficients. The EZW encoder uses threshold to classify significant and non significant coefficients. The coefficient x is said to be significant, if $|x| < T$ else significant coefficient.

4.2. Edge detection process using wavelet transform

In traditional edge detectors such as sobel, Canny, Prewit and Robert, the kernel matrix is used to detect the edges. But in all traditional methods there is a false identification of edges and also requires huge memory space but using the wavelet transform the edges are traced at different orientation with less number of coefficients which utilizes the less memory space. Initially original image is decomposed into approximated image and detail image. This method is generally called as Wavelet based modulus maxima method. In this method, only the vertical and horizontal details are taken, then modulus maxima is calculated using the following equation

$$f(u,v,2^j) = \sqrt{|f_h(u,v)|^2 + |f_v(u,v)|^2} \quad (5)$$

The gradient angles for the same pair of coordinates are calculated using the following equation

$$\alpha = \tan^{-1}\left(\frac{f_v(u,v)}{f_h(u,v)}\right) \quad (6)$$

$f_v(u,v)$ and $f_h(u,v)$ are the horizontal and vertical details obtained from wavelet transform.

4.3. Contourlet transform in interpolation

The directional characteristics are considered to be important in certain image processing applications such as interpolation, segmentation etc. Do and Vetterli [14] developed the *contourlet representation* base on 2D non separable directional filter banks, which can trace the directional parameters of the image having smooth contours [15]. In addition contourlet provides iterated filter banks, which makes computationally efficient in interpolation. Contourlet transform uses Pyramidal Directional Filter Bank (PDFB) which decomposes images into directional sub-bands at multiple scales .The PDFB is a combination of laplacian pyramid and directional filter bank. The direction filter bank is a sampled filter bank, which decomposes the image in powers of two at desired direction.

Novel Interpolation Using Adaptive Wavelet Based Contourlet Transform:

1. The following steps are used in interpolation (see fig3) using wavelet based contourlet transform

Estimate the value of xo, which is obtained by the adaptive wavelet transform as the initial estimate of the compressed image.

2. Improve the quality of the image by again interpolating using observation details (low frequency) and sparsity details (high frequency), which is transmitted by the transmitter. The sparseness details are obtained from the contourlet transform.
3. Initialize the threshold value T_k and increment by the specified value for each iteration, such that pixel values are obtained at different angles.

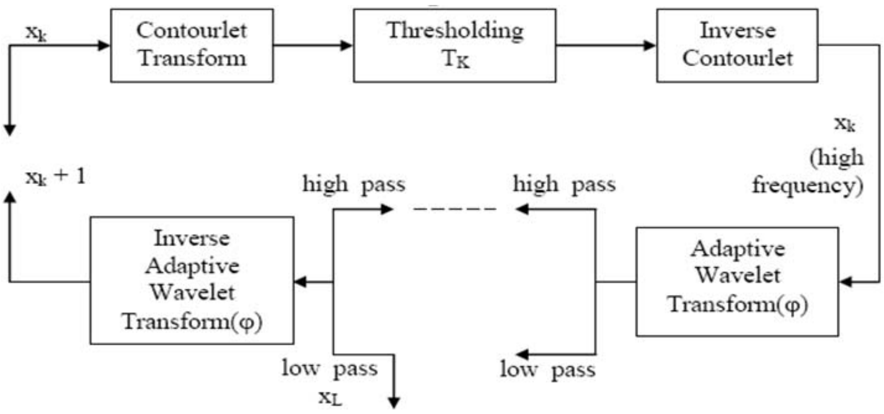

Fig2: Block diagram of Wavelet based Contourlet Transform

5. Algorithm for Proposed Compression System

Step 1: Read the image and convert the image into gray image if it is a RGB image.
Step 2: Extract the edges of the given image and their positions using any one of the edge detecting methods by choosing the suitable coefficients and threshold (section4.2).
Step 3: Extract the valuable edge positions i.e. only the coefficients other than zero.
Step 4: Decompose the original image by 2 levels using Haar Wavelet Transform (section 4.1).
Step 5: Develop a zero tree and scan the coefficients of the wavelet coefficients to yield the compressed data using EZW encoder.
Step6: Calculate the compression ratio using the following equation

Compression ratio= ori_bytes / comp_bytes (7)

Step 7: At the receiver decode the encoded data using EZW decoder and compute the inverse Wavelet Transform using IADWT.
Step8: Copy the corresponding edge information to the decomposition levels in pixel mapping to reconstruct the image.
Step 9: The reconstructed image has less number of information, using the initial value obtained through wavelet transform interpolate (section 4.4) the lost coefficients to construct the original image.
Step 8: Calculate the PSNR using the following equation

$$PSNR = 10*\log10\,(255*255 / MSE) \quad (8)$$

6. Results and Discussions

Two of the error metrics used to compare the various image compression techniques are the Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR). The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is a measure of the peak error. A lower value for MSE means lesser error, and as seen from the inverse relation between the MSE and PSNR, this translates to a high value of PSNR. Logically, a higher value of PSNR is good because it means that the ratio of Signal to Noise is higher. In the performance analysis of the proposed method along with the existing method, it seemed to be the proposed method is better in both compression factor (CF) and peak signal- to - noise ratio (PSNR) values (see table1).

Table1: Comparison Between Various Methods (H1-Hetrogeneous Approach Without Interpolation, H2-Heterogeneous Approach With Interpolation)

Images	**PSNR**			**Compression ratio**		
	Existing	H_1	H_2	Existing	H_1	H_2
Cameraman	16.2	20.3627	24.1358	13.2:1	15.3:1	16:1
Lena	16.4	22.0244	24.8948	14:1	14.4:1	16.2:1
Baboon	16.8	19.7092	20.9904	15:1	15.6:1	16:1
Women	17.3	19.9355	24.8965	14.2:1	15.2:1	15.9:1

7. Conclusion

The Features of the image plays an important role in image representation. In this paper it is been proposed the use of edge detection through wavelet transform in feature preservation and adaptive Wavelet transform for image decomposition, which increases the Compression ratio. Further the use of preservation at various positions increases the PSNR. The usage of edges at appropriate places and in different ideologies may increase or decrease the compression ratio and peak signal- to -noise ratio values. The interpolator has also been used to enhance the image at the receiver. PSNR and Compression ratio are increased using the EZW coder. All kinds of Texture and natural photographic images can be compressed using the proposed system. The further works can be carried out by selecting the appropriate encoding technique and orientations to achieve better PSNR, better transformation Coefficient can also be used to increase the peak signal- to -noise ratio value. Irrespective of edges some other Geometric parameters can also be taken in to consideration for preservation in the noisy environment.

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