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DWT BASED IMAGE COMPRESSION USING QUADTREE DECOMPOSITION AND HUFFMAN ENCODING

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ABSTRACT

In this paper the image compression technique uses both Wavelet transformation technique and Quad tree decomposition technique simultaneously, for better compression performance. Here the compression ratio (CR) as well as the peak signal to noise ratio (PSNR) value has been better than any one of the techniques, that will be shown in the simulation result. Generally, discrete wavelet transformation (DWT) decomposes an image into a hierarchical subbands system consists of some significant coefficients of the image depending upon space frequency localization technique. A quadtree decomposition technique is then applied on the resultant image of the wavelet decomposition, which is divided into some blocks that contains image information and other details depending on a given threshold, followed by an entropy encoding technique which finally compress the image. The simulation is done by mat lab.

KEYWORDS

DWT, Quad tree decomposition, Hierarchical sub band system, CR.

1. INTRODUCTION

At present scenario, storage efficiency become the leading part in the information world. Hence the data compression technique is going to take an important part in the multimedia revolution. Image compression technique is an important part of this data compression technique. There are so many important image compression techniques which are categorized mainly into two parts, one is lossless compression technique and another one lossy compression technique (Morlet, 1983). In lossless compression technique, it is possible to recreate the proper replica of the original image from the compressed data, without losing any data in the compression process. This is very much related to the entropy coding. Though by a lossless compression technique is useful to retrieve data properly but it gives a poor compression ratio. In lossy compression, it is not possible to reconstruct the exact replica of the original image. Some data is lost here due to some changeable appearance of the image. Due to this data loss there is a drastically reduction in storage of the compressed image. This technique gives a high compression ratio. It has a huge application in the communication like television broadcasting, videoconferencing etc. Here both the techniques are used without any compromising the image quality and provides less complexity. Basically, the main usefulness of the hierarchical data structures is the focusing ability on the important subsets of an image. This technique is very efficient to represent data significantly and reduces time complexity. In comparison with another compression technique this hierarchical sub band systems concept has better clarity and is easy to implement. In this paper firstly it is used the wavelet decomposition which divides the image into some subbands that contain significant coefficients of the image at

lower resolution level (Charles, 1992). A Quad tree decomposition technique divides the coefficients into some information blocks at different spatial position based on a given threshold. then the blocks are Huffman coded that is nothing but a entropy coding, a main issue of lossless compression. Huffman coding is based on the probabilities occurrence of the symbols that is actually frequency localization. This concept is possible because the probabilities are always scaled integer where the frequencies are integer. It takes some additional storage of some few bytes on the output but through this process space frequency localization is done by maintaining a given threshold which is an crucial factor for image compression. Image content mainly exist in the lower frequency resolution of the image. Wavelet transform uses multiresolution analysis to decompose the image into subband with the help of four type filter. This multiresolution analysis is the main basis of the DWT which uses some scaling function and wavelet function. After decomposition of the image by DWT, the image now decomposed into some coefficients that are much decorrelated and energy efficient. Hence image quality become better and gives a higher compression ratio. PSNR is also calculated here that is also very satisfactory. The space frequency localization technique is very efficient to represent an image with lower coefficients also.

2. WAVELET ANALYSIS

Presently, in the field of both mathematics and engineering, the subject wavelet becomes attractive. Like Fourier analysis, the wavelet also has two mathematical entities: 'integral wavelet transform' and 'the wavelet series'. In a square integrable space, suppose a real valued function

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(multiplication of two scalar function) exists there and summed up over that space the there will be got a series of summation and will be realized shifted and a scaled function of the basic function. These two functions are related to each other by an expression or equation is called the wavelet transform. The equation is

$$[\Phi_{u,v}(y) = 2^{\frac{u}{2}} \Phi(2^u - v)]$$

If 'u' is going to be fixed that means for a particular scaling value, if there is a variations in shifting parameter value, then there will be got some subspace and difference space in a square integrable space $L^2(R)$, that is nothing but a conceptual idea from the abstract mathematical concept. From these two concept of the space it can be developed the idea of the 'Scaling function' and the 'Wavelet function'. The equation of the both function are written thereby

$$\Phi(n) = \sum_b r_\phi(n) \sqrt{2} \Phi(2n - b) \quad \Psi(n) = \sum_b r_\psi(n) \sqrt{2} \Phi(2n - b)$$

Here the ' ϕ ' is called the **Scaling function** and the ' ψ ' is called the **Wavelet function**. They both are the different class of the function and the basic function is the summation of the higher order of the function. That's mean any function in the square integrable space $L^2(R)$, is going to be approximate by the summation of the shifted version of the scaling function, that is actually wavelet function.

2.1 Discrete Wavelet Transformation

Discrete wavelet transform is an easiest way of compression where the wavelet is used as tool to vary the coordinate system where the signal is presented from one domain to another domain. DWT has a multiresolution nature that is very much applicable where the degradation of tolerability and scalability are important (Himanshu et al., 2014). This multiresolution nature of the DWT is very efficient to represent the finer quality of the image. Multiresolution is nothing but the iterative application of the filter. From the above two equation, it is got the two terms ' $r_\phi(n)$ ' and ' $r_\psi(n)$ '. Actually, they are the two types of filter, 'Low pass filter' and 'high pass filter' respectively. In 2 dimensional space, Image is a nonstationary signal. An image is represented by DWT as a summation of wavelet function at different location and space. Now through some rigorous calculation of the abstract mathematics it can be obtained two coefficients ' $s_\phi(p, q)$ ' and ' $s_\psi(p, q)$ ' around which the whole DWT concept is evolving. These two coefficients can easily be understood by the concept of wavelet or concept of filtering applied to the shifted and scaled version of the wavelet function. The equations are

$$s_\phi(p, q) = \sum_l r_\phi(l - 2q) s_\phi(p + 1, l)$$

$$s_\psi(p, q) = \sum_l r_\psi(l - 2q) s_\phi(p + 1, l)$$

2.2 Multiresolution Analysis

The mathematical analysis of DWT shows the concept of filtering applied on the image. The image information mainly exists at the low frequency range of an image and gradually lowers to the higher frequency range. By using the filtering concept the resolution analysis is done from finer to coarser. Figure 1

Figure 1: 2-D wavelet decomposition

shows the basic block diagram of the multiresolution analysis. In this analysis four types of filtering concepts are used. An efficient filter bank concept helps to build up this filtering concept.

$\Phi(b_1, b_2) = (\phi_1)\Phi(b_2)$: Concept of low pass filtering in both direction;
 $\Psi^H(b_1, b_2) = \Psi(b_1)\Phi(b_2)$: High pass filtering along b_1 and low pass filtering along b_2 ;
 $\Psi^V(b_1, b_2) = \Phi(b_1)\Psi(b_2)$: Low pass filtering along b_1 and high pass filtering along b_2 ;
 $\Psi^D(b_1, b_2) = \Psi(b_1)\Psi(b_2)$: Concept of high pass filtering along both direction.

By applying this filtering concept on an image, an image is subdivided into four subbands named as LL, LH, HL, HH (David, 1995).

Figure 2: 1st level DWT

According to the above figure 1 this filtering concept is iteratively applied on the lower frequency sub band of the image, as image content full in the lower frequency range.

Figure 3: Sub band relationship

Actually the hierarchical subband system is developed from this iterative application of the filter bank. Figure 3 Shows the sub division of the image.

3. QUADTREE DECOMPOSITION

Quad tree decomposition is a very well-known and established technique in the image compression area. It is very useful in the fractal image compression also which contains a nonlinear infinite and complex pattern in the image. A natural grey-scaled image can be segmented into some regions with some variety of information. A quadtree technique can divides this image into 2D segmentation depending upon a given threshold (Samet, 1984). It divides the whole image into four rectangle or square shaped block firstly. Then the process is done iteratively with the boundation of the calculated threshold and generates the domain and range blocks where the domain blocks are four times greater than the range blocks. Figure 4 shows this decomposition analysis

Figure 4: Quad tree decomposition

Then the domain blocks are being searched for the suitable match with each range block. In this searching process for each range block, a suitable number for domain block and significant information are recovered to store in that range block. Thus, iteratively employing this process to the resultant image of the DWT, the image is segmented into range blocks by dividing it into square blocks. Each block is then examined to find either it fulfil the conditions of uniformity or not and if does then the image cannot divide any further. This process the Quad tree decomposition technique construct a tree data structure. i.e. each node contains four children and so on.

Figure 5: Quad tree data structure

This encoding technique codes both the parent information and the sibling information. This data structure follows the stage of spatial segmentation and presents an image composed of pixels matrix where the pixel value will be '0' or '1' (Bohong and Yung, 2010). A root node represents an image section and if pixel value will not be '1' or '0' then segmentation occur repetitively. Thus, Quad tree decomposition technique approximates the wavelet coefficients (resultant image) nicely by arranging them in similar spatial directions. The method is very time consuming by searching a huge database to calculate a suitable domain block for every range block. Hence, here it is calculated the mean value of each block with their respective coordinates.

The every node is purely assigned by the intensity value of the particular region of the image. It is done by two procedures like top-down and bottom-up procedures (Shweta and Megha, 2014).

Figure 6: quadtree decomposition (a) top down technique; (b) bottom up technique

In Fig. 6, both the processes are illustrated where the bottom up is the better one. This divisioning is also familiar as a Q-Tree. In the tree structure the characterizing intensity is always uniform.

4. HUFFMAN ENCODING

Huffman encoding technique is used for compressing data. This technique converts character into binary string in a optimised way. It is a statistical coding to reduce the amount of bits that are essential to present a string of symbols. The Huffman code procedure is based on the two rules. Firstly, frequent symbols have shorter code words than less frequent symbols. The less frequent two symbols will have the same length. Secondly, the designing of the Huffman code is a repetitive process where it is merged the lowest possible symbols until only two symbols are left which are probable (Kekre et al., 2011). Thus, it is generated a code tree and by labelling them obtained the Huffman code. Hence, by generating a list of symbols of all alphabet in descending order. This procedure generates an optimal code for the symbols' set and possible subjects to the constraint for that the symbols can be encoded one by one.

5. PROPOSED ALGORITHM

Step 1: Read the i/p colour image.

Step 2: Convert the colour image into gray scale image.

Step 3: Apply 1st level DWT on image for decomposing into four segments.

Step 4: DWT is applied for 2nd level decomposition and get the resultant image LL2.

Step 5: Apply quad tree decomposition on the resultant image after resizing it.

Step 6: Decomposes the image by using quadtree of quantization is 0.2; min dimension and max dimension are 2 and 64 respectively.

Step 7: Register the values of coordinates, block size and mean values after quadtree decompositions.

Step 8: Apply Huffman coding to create binary stream and implant the data by using LSB and calculate the PSNR and CR.

6. WORK FLOW DIAGRAM

Figure 7: Block diagram for proposed algorithm

7. EXPERIMENTAL RESULTS AND DISCUSSION

The hierarchical sub band system of image coefficient with an entropy coding is very efficient to compress an image with a high compression ratio and peak signal to noise ratio. The encoding technique is done by using MATLAB. All the numerical analysis and mathematical calculations are done by MATLAB. Here take a standard Lenna image for the proposed work.

7.1 I/P colour Image and Gray Scale Conversion:

Figure 8: RGB image and grey scaled image

7.2 After 1st level DWT

Figure 9: 1st level DWT

7.3 After 2nd level DWT

Figure 10: 2nd level DWT

7.4 Quadtree Decomposition

Figure 11: Quadtree Decomposition

7.5 Final compressed result

Figure 12: Final compressed image

Figure 13: Software simulated CR and PSNR

Test Image	CR	PSNR
	111.8286	22.1432
	75.204	23.3498
	76.2650	29.3436
	77.548	26.9930
	114.90	23.3014

8. CONCLUSION

From the simulated value of the compression ratio and the peak signal to noise ratio it can be concluded that the proposed algorithm works efficiently. Here it is used the biorthogonal DWT (bior6.8) technique that gives better PSNR than the others biorthogonal DWT techniques only for the use of quadtree decomposition at next level. In both the concept the hierarchical sub band system is very significant. The quality of image and time is depended on the block size according to their dimensions and quantization value. The proposed work has been tested by employing it to some practical image. By changing some dimensions of the image it can also measure the threshold range.

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