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Edge Preserved Image Compression Technique Using Wavelet and Edge Based Segmentation



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Abstract - This paper presents a new approach of edge preserving and edge based segmentation for compression of images using Modified Fast Haar wavelet transform (MFHW) and Bit Plane Encoder to elevate the compression ratio with high picture quality. The edges of an image are preserved to increase the PSNR, and then the detected edges are used to segment the foreground and background images. The Foreground of the image is given more importance than the background images. A wavelet transform is used to extract the redundant information at low frequency and a matching Bit Plane encoder is used to code the segments of the image at different quality levels. The Proposed method highly preserves quality of the foreground image. Normal compression algorithms will not preserve the high frequency details such as edges, corners etc., in this method edges are preserved and used for segmenting the layers of the original image. The two level Fast haar Wavelet transform is used to decompose the image at different frequency levels, which has high multi-resolution characteristics. The proposed method increases both the compression ratio and PSNR.

I. INTRODUCTION

Computer graphics applications, particularly those generating digital photographs and other complex colour images, can generate very large file sizes. Issues of storage space, and the need to rapidly transmit image data across networks and over the internet, has led to the development of a range of image compression techniques in order to reduce the physical size of the files without degrading the quality of the image to an unacceptable level. Image compression, intends to yield a compact representation of an image. The reduction in file size allows more images to be stored in a certain amount of disk or memory space. It also reduces the time necessary for images to be sent through the channel.

In image compression, there is a relaxation of usage of more number of bits to represent regions of interests such as *edges* of an image, which indirectly implies the details of image. Higher compression ratios can only be achieved at the expense of higher distortion that degrades the quality of the image. This trade-off between the high compression and the quality of an image should be handled. To meet the challenges of achieving even high compression ratio along with the better image quality the better method of processing the image should be made out. In the transform-based compression techniques, the cost function is the energy or frequency contents of the image, which is concentrated in the lower values. Compression is achieved through the elimination of the higher energy or frequency values, which are less concentrated and therefore deemed less important.

Wavelet transformation (WT) [1], [2]-[7], vector quantization (VQ) [8] and different encoding approaches

are generally used in addition to numerous other methods in image compression. The problem in lossless compression method is that, the compression ratio is very less; where as in the lossy compression the compression ratio is very high but the quality of the image is lost. Hybrid image compression [9]-[10] incorporate diverse compression systems like PVQ and DCTVQ in a single image compression. The proposed method uses lossy compression method with various quality levels based on the edges and Modified fast Haar Wavelet (MFHW) Transformation.

The proposed method uses both edge preservation and segmentation based on edges, which makes a balance on compression ratio and image quality by compressing the desired portions of image with high quality. In this approach the main subject in the image is very significant than the background image. Considering the significance of image constituents, and the influence of smoothness in image compression, this technique segments the image as main subject and background, then the background of the image is subjected to low quality lossy compression and the main subject is compressed with high quality lossy compression. There are numerous amount of work on image compression is carried out both in lossless [11] [12] and lossy [13] compression. Very limited research works are carried out for Hybrid Image compression [14]-[15].

The reminder of this paper is structured as follows. The basic introduction to Wavelet transformation is briefly described in section 2. The Edge detection process is presented in section 3. The segmentation process is explained in section 4. The bit plane encoder is explained in section 5. The proposed method is

explained in Section 6 and then concluded with the results in section 7 and 8 respectively.

II MODIFIED HAAR WAVELET TRANSFORM

A. Introduction to Haar Wavelet Transform

Wavelets are mathematical tools for hierarchically decomposing functions. Wavelet Transform has been proved to be a very useful tool for image processing in recent years. It allows a function which may be described in terms of a coarse overall shape, plus details that range from broad to narrow. The most distinctive feature of Haar Transform lies in the fact that it lends itself easily to simple manual calculations. The wavelet transform is often used for signal and /or image smoothing keeping in view of its “energy compaction” properties, i.e. large values tend to become larger and small values smaller, when the wavelet transform is applied. Since the Haar Transform is memory efficient, exactly reversible without the edge effects, it is fast and simple. As such the Haar Transform technique is widely used these days for wavelet analysis.

The Haar Transform (HT) is one of the simplest and basic transformations from the space domain to a local frequency domain. A HT decomposes each signal into two components, one is called average (approximation) or trend and the other is known as difference (detail) or fluctuation. A precise formula for the values of first average sub-signal, $a^1 = (a_1, a_2, a_3, \dots, a_{N/2})$ at one level for signal of length N i.e. $f = (f_1, f_2, f_3, \dots, f_N)$ is

$$a_n = \frac{f_{2n-1} + f_{2n}}{\sqrt{2}}, n = 1, 2, 3, \dots, N/2 \quad (1)$$

and the first detail sub-signal $d^1 = (d_1, d_2, d_3, \dots, d_{N/2})$ at the same level is given as

$$d_n = \frac{f_{2n-1} - f_{2n}}{\sqrt{2}}, n = 1, 2, 3, \dots, N/2 \quad (2)$$

The Haar wavelet transform produces four areas A, H, V and D respectively. A (approximation area) includes information about the global properties of analysed image. Removal of spectral coefficients from this area leads to the biggest distortion in original image. H (horizontal area) includes information about the vertical lines hidden in image. Removal of spectral coefficients from this area excludes horizontal details from original image. V (vertical area) contains information about the horizontal lines hidden in image. Removal of spectral coefficients from this area eliminates vertical details from original image. D (diagonal area) embraces information about the diagonal details hidden in image. Removal of spectral coefficients from this area leads to minimum distortions in original image.

B. Modified Fast Haar Wavelet Transform.

Fast Haar Transform (FHT) involves addition, subtraction and division by 2, due to which it becomes faster and reduces the calculation work in comparison to HT. For the decomposition of an image, we first apply 1D FHT to each row of pixel values of an input image matrix. These transformed rows are themselves an image and we apply the 1D FHT to each column. The resulting values are all detail coefficients except for a single overall average coefficient.

In MFHWT, first average sub-signal,

$a^1 = (a_1, a_2, a_3, \dots, a_{N/2})$ at one level at a signal of length N i.e. $f = (f_1, f_2, f_3, \dots, f_N)$ is

$$a_n = \frac{f_{4m-3} + f_{4m-2} + f_{4m-1} + f_{4m}}{4}, m = 1, 2, 3, \dots, N/2 \quad (3)$$

And first detail sub-signal $d^1 = (d_1, d_2, d_3, \dots, d_{N/2})$ at the same level is given by

$$d_n = \frac{(f_{4m-3} + f_{4m-2}) - (f_{4m-1} + f_{4m})}{4}, m = N/2, \dots, N \quad (4)$$

Here four nodes are considered at a time instead of two nodes as in HT and FHT. The author has considered the values of $N/2$ detail coefficients zero in each step than to find the $N/2$ detail coefficients by FHT as in [16].

III EDGE DETECTION

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. Classical methods of edge detection involve convolving the image with an operator (a 2-D filter), which is constructed to be sensitive to large gradients in the image while returning values of zero in uniform regions. There are an extremely large number of edge detection operators available, each designed to be sensitive to certain types of edges. Variables involved in the selection of an edge detection operator include Edge orientation, Noise environment and Edge structure. The geometry of the operator determines a characteristic direction in which it is most sensitive to edges. Operators can be optimized to look for horizontal, vertical, or diagonal edges. Edge detection is difficult in noisy images, since both the noise and the edges contain high frequency content. Attempts to reduce the noise result in blurred and distorted edges. Operators used on noisy images are typically larger in scope, so they can average enough data to discount localized noisy pixels.

In our proposal Canny edge detector is used which has high localization and error free characteristics. The Canny edge detection algorithm is known to many as the optimal edge detector.

Canny's intentions were to enhance the many edge detectors already out at the time he started his work. He was very successful in achieving his goal and his ideas and methods can be found in his paper, "A Computational Approach to Edge Detection"[17]. In his paper, he followed a series of steps to detect the valuable edge points as follows

Step1: Read the image, Filter out the noise in the image and smoothing is done using Gaussian filter.

Step2: Find the gradient of the image in the x and y direction and respectively and hence calculate the magnitude using below equation

$$\text{—————} \quad (5)$$

Step3: Determine the gradient of the image using following equation

$$\text{—} \quad (6)$$

Step4: Rotate the edge direction to a direction that can be traced in an image.

Step5: Suppress the non maximum value, which is not considered to be an edge.

Step6: Using two threshold and to eliminate the unwanted edge points. Any pixel between thresholds is assumed to be an edge pixel and other pixel points are set to zero.

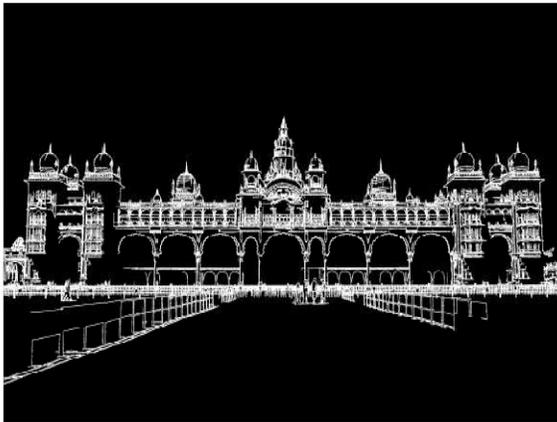


Figure 1: Edge detected image Using Canny Detector

IV. EDGE BASED SEGMENTATION

The segmentation of foreground and background image is computed after detecting the edges using Canny Edge Detector. The scan line algorithm is applied to fill in the space surrounded by the edges.

The horizontal and vertical scanning is made individually and the result is combined to get the foreground image. In horizontal scan line process, the scanning starts from left to right to find non-zero value in the matrix E. For scanning a line or row i, the column j varies from 1 towards n, and test for non-zero value in $E_{i,j}$, when non zero value of $E_{i,j}$ is found, set j as the starting column L, now the scan proceeds from right to left to find the right most edge pixel, the column starts from n towards 1 to find a non-zero element at row i, when the non-zero $E_{i,j}$ is found, set j as the ending column W. Now fill the line from $E_{i,L}$ to $E_{i,W}$. After iterating the process for all the rows in the image, the horizontally filled image would be ready, in the same way vertical scan line process starts from top to bottom that is keeping the column fixed and change the row from 1 to m. After finishing vertical scan line procedure, the two images are combined by logical AND operation. The resultant image is a binary image in which the foreground is denoted by 1 and the background is denoted by 0. The segmented image is used in the proposed algorithm to resolve whether to compress a pixel using high quality compression or not.

V. BIT PLANE ENCODER

After applying the MFHWT, the wavelet transformed coefficients are either rounded to the nearest integer (when the floating-point transform is used), or scaled using the weighting factors (when the integer transform is used). The Round-off operation makes the compression a lossy compression. On the other hand, the scaled operation after the integer wavelet transform makes the compression a lossless compression. The rounded or scaled coefficients are first grouped into blocks. Several consecutive blocks are grouped into a segment. Segments are then encoded by the bit-plane encoder. The BPE successively encodes bit planes of coefficient magnitudes in a segment, inserting AC coefficient sign values at appropriate points in the encoded data stream. Coding of a bit plane is performed in stages number 0-4. A coded bit plane first consists of all the stage 0 bits (if any) in the segment, then all off the coded stage 1 bits in the segment, and so on, finishing with all of the encoded stage 4 bits in the segment. The output bit stream is then formed and sent. The formation of a coding block is shown in Figure 3 [18]. The bit plane encoder is mainly used in satellite images for achieving high quality of pictures. This when combined with adaptive wavelet Transform it provides progressive compression ratio with picture quality, comparatively with other coders. The coding time is reduced using Bit Plane Encoder.

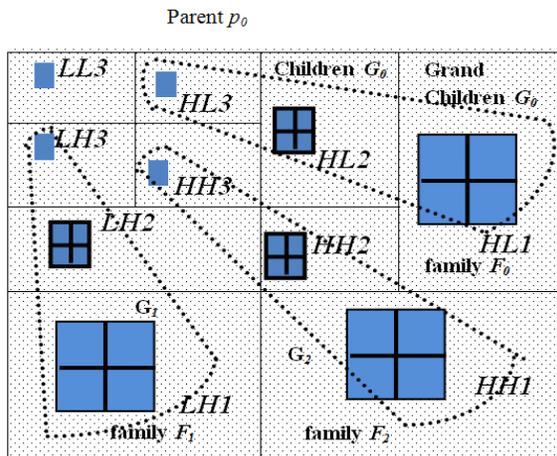


Fig2: Formation of Block.

V PROPOSED IMAGE COMPRESSION METHOD

In the proposed method, the input image is segmented into foreground and Background image using edges, which are detected using canny edge detector and the residual image, is compressed using MFHW transform as shown in figure2. From the input image the edges are detected initially, the edge detected images are traced to form the background and foreground image. The valuable edge points are transmitted through the channel or stored separately in the buffer. The foreground image is transformed using MFHWT and coded using Bit plane encoder.

Algorithm

1. Read the image and detect the edge of the image using canny detector as shown in section3.
2. Store the valuable edge points in the buffer.
3. Segment the image into foreground and background image using the edges detected as shown in section4.
4. Take the modified fast haar wavelet transform for the foreground image to extract the contrast information as shown in section 2.
5. Encode the Transformed coefficient using bit plane encoder, giving high importance to the foreground image.
6. Transmit the valuable edge points and encoded information in the ideal noiseless channel.
7. Perform decoding, inverse transform at the reconstruction side.
8. Collect the edge information from the buffer.
9. Trace the position of the edges.
10. Map the pixel positions of the edges and the transformed coefficients

The above algorithm gives best results in noisy and noiseless environment; the bit plane encoder encodes the image at different levels according to the layers of the image. The different layers are represented by using bit map algorithms. The mapping is done using the wavelet coefficients extracted in step4. The precision of the bit plane encoder depends on the coefficients of wavelet. Bit plane encoder codes the layer of images with different resolution according to the wavelet coefficients obtained using the MFHWT. The valuable edge points are those whose pixel values other than zero, the position of the valuable pixel points are transmitted. The segmentation based on edges extracts only the background images according to the threshold. The proposed method is tested by considering the noiseless environment. Some characteristics of the communication channel can be

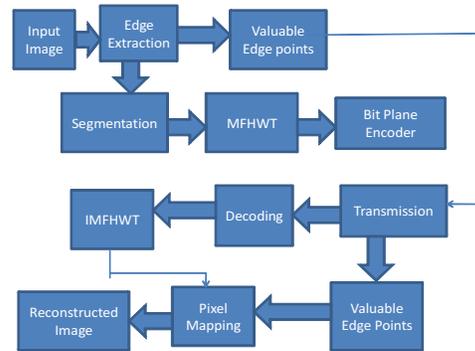


Fig3: Proposed Method Block Diagram

VI RESULTS AND DISCUSSIONS

The edge preserved image compression using wavelet and edge based segmentation is implemented using MATLAB with various test images such as Lena, baboon, cameraman etc. The results are computed in terms of Compression ratio and PSNR. The below tables and figures shows the outcomes of the proposed algorithm and it is compared with the existing techniques. The results shows both the compression ratio and PSNR is high than the existing techniques.

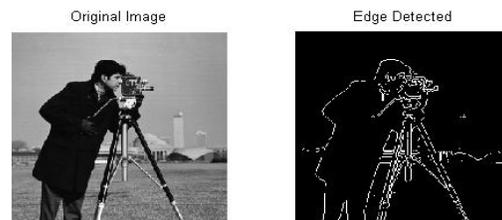


Fig4: Original image and edge detected image using canny.

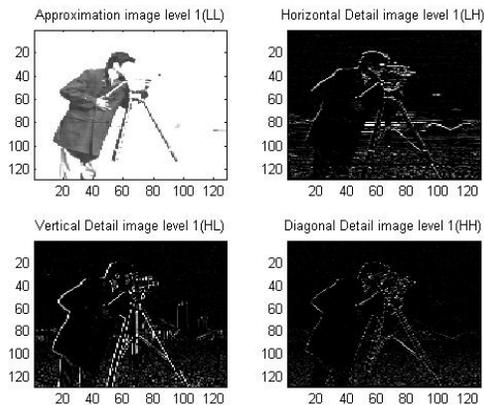


Fig5: Transformed and segmented image using Wavelet.

The below table gives the comparison between the existing method and proposed method in terms of compression ratio and PSNR. From the table it could be observed that the compression ratio is high than the existing method and also the PSNR is maintained due to the preservation of edges. Due to the edge preservation and MFHW transform the process speed is also increased which is noticed in the run time. By fixing the appropriate threshold more edges could be preserved such that PSNR could be improved.

Table-1 Compression ratio and PSNR values attained By Proposed and Existing method

Image	Existing method		Proposed method	
	CR	PSNR	CR	PSNR
Lena	4.34	22.40	16.1	25
Cameraman	2.98	23.14	15.4	26
Baboon	7.69	22.36	15.3	24.5
Salt and pepper	4.84	23.4	7.5	26.8

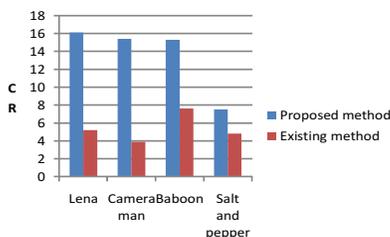


Fig6: Compression ratio attained for test images.

VII. CONCLUSION

The compression ratio of proposed method is better than existing method. The quality of the image is also improved in proposed method than existing method in terms of PSNR. The edges are the important parameters in consideration of the peak signal- to -noise ratio values. The PSNR could be further increased by considering the background details and some high frequency components. The Proposed method is appropriate for larger insignificant background images and certain level of loss is tolerable in the background of the image. The proposed method can be extended for colour images rather than gray scale image. The method can also be extended with other features of the image.

REFERENCES

- [1] Xiwen OwenZhao, Zhihai HenryHe, "Lossless Image Compression Using Super-Spatial Structure prediction", IEEE Signal Processing Letters, vol. 17, no. 4, April 2010 383.
- [2] Jaemoon Kim, Jungsoo Kim and Chong-Min Kyung , "A Lossless Embedded Compression Algorithm for High Definition Video Coding" 978-1-4244-4291 / 09 2009 IEEE. ICME 2009.
- [3] Rene J. van der Vleuten, Richard P.Kleiorstt ,Christian Hentschel,t "Low-Complexity Scalable DCT Image Compression", 2000 IEEE.
- [4] K.Somasundaram, and S.Domnic, "Modified Vector Quantization Method for image Compression", 'Transactions On Engineering, Computing And Technology Vol 13 May 2006
- [5] Mohamed A. El-Sharkawy, Chstian A. White and Harry , "Subband Image Compression Using Wavelet Transform And Vector Quantization", 1997 IEEE.
- [6] Amir Averbuch, Danny Lazar, and Moshe Israeli , "Image Compression Using Wavelet Transform and Multiresolution Decomposition", IEEE Transactions on Image Processing, vol. 5, NO. 1, Jan 1996.
- [7] Jianyu Lin, Mark J. T. Smith, " New Perspectives and Improvements on the Symmetric Extension Filter Bank for Subband /Wavelet Image Compression", IEEE Transactions on Image Processing, vol. 17, NO. 2, Feb 2008.
- [8] Xin Li, , and Michael T. Orchard " Edge-Directed Prediction for Lossless Compression of Natural Images", IEEE Transactions on Image Processing, vol. 10, NO. 6, Jun 2001.
- [9] Marta Mrak, Sonja Grgic, and Mislav Grgic, "Picture Quality Measures in Image Compression

- Systems”, EUROCON 2003 Ljubljana, Slovenia, 0-7803-7763-W03 2003 IEEE.
- [10] Alan C. Brooks, Xiaonan Zhao, , Thrasyvoulos N. Pappas., “Structural Similarity Quality Metrics in a Coding Context: Exploring the Space of Realistic Distortions”, IEEE Transactions on Image Processing, vol. 17, no. 8, pp. 1261–1273, Aug 2008.
- [11] David Salomon, “Data Compression , Complete Reference”, Springer-Verlag New York, Inc, ISBN 0-387-40697-2.
- [12] Roman Kazinnik, Shai Dekel, and Nira Dyn , ”Low Bit-Rate Image Coding Using Adaptive Geometric Piecewise Polynomial Approximation”, IEEE Transactions on Image Processing, vol. 16, NO. 9, Sep 2007.
- [13] Eddie Batista de Lima Filho, Eduardo A. B. da Silva Murilo Bresciani de Carvalho, and Frederico Silva Pinagé “Universal Image Compression Using Multiscale Recurrent Patterns With Adaptive Probability Model” , IEEE Transactions on Image Processing, vol. 17, NO. 4, Apr 2008.
- [14] Alan C. Brooks, Xiaonan Zhao, , Thrasyvoulos N. Pappas., “Structural Similarity Quality Metrics in a Coding Context: Exploring the Space of Realistic Distortions”, IEEE Transactions on Image Processing, vol. 17, no. 8, pp. 1261–1273, Aug 2008.
- [15] Hong, S. W. Bao, P., “Hybrid image compression model based on subband coding and edgepreserving regularization”, Vision, Image and Signal Processing, IEE Proceedings, Volume: 147, Issue: 1, 16-22, Feb 2000.
- [16] Chang, P. and P. Piau, 2007. Modified Fast and Exact Algorithm for Fast Haar Transform. Proceedings of World Academy of Science, Engineering and Technology, 26: 509-512.
- [17] J. F. Canny. “A computational approach to edge detection”. IEEE Trans. Pattern Anal. Machine Intell., vol.PAMI-8, no. 6, pp. 679-697, 1986.
- [18] Minh N.Do and M. Vetterli. Pyramidal directional filter banks and curvelets. IEEE international conference on image processing. Greece, Oct 2001.

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