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Performance Analysis of Wavelet Families for Lossless Image Compression

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Abstract- **This paper presents performance analysis of various wavelet filters namely Dmey, Daubichies, Symlets, Coiflets, Haar, Biorthogonal, with various decomposition level of Discrete Wavelet Transform for cameraman test images . The recent development in the digital electronics and computer engineering has resulted in generation of higher amount of data in the form of digital. Generally high resolution images are needed in many areas such as remote sensing, criminal investigation, medical imaging etc. This motivates the requirement of compression in large amount. The main aim of this research work is to obtain best quality of decompressed images even at very low bit rates. Now a days, Discrete Wavelet Transforms has emerged as a popular technique for image compression. The Discrete Wavelet Transform can be composed of any function that satisfies requirements of multi-resolution analysis. It means that there exists a large choice of wavelets depending on the choice of wavelet function. The Discrete Wavelet Transform has high de-correlation and energy compaction efficiency. Traditionally, In Wavelet Transform, we uses Root Mean square error (RMSE) to evaluate similarity of image blocks, but the similarity evaluated by MSE usually differs from human visual system (HVS). This paper presents a comparative study of various wavelet families for Lossless image compression and evaluate the results in terms of compressed image quality, PSNR, RMSE as considering as subjective quality measures and Compression Ratio.**

Index Terms— **Discrete wavelet transform (DWT); Peak signal to noise ratio;(PSNR); Root Mean square error(RMSE) Compression Ratio(CR).**

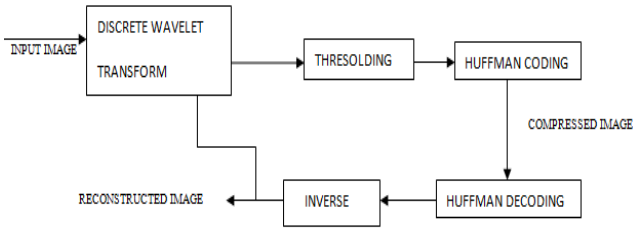
I. INTRODUCTION

Multimedia applications like text, image, audio and video are represented in digital form. This occupies larger space in memory. So, there is a need to compress this large amount of data. Image compression is an important research area for many years due to increasing demand on transfer and storage of [1].The aim of image compression is to reduce the amount of data required to represent digital image. Thus image compression is very importance and necessity. *Image compression has two types (1) lossless compression and (2) lossy compression.* Lossy image compression algorithms are applicable, when the exact reconstruction of an image is not expected. These algorithms are usually based on transform methods. In recent years, a considerable effort have been made to design image compression method in which the main goal is to obtain good quality of decompressed images even at very low bit rates.

The basic aim of image compression is to reduce the storage requirement while maintaining acceptable image quality. *DWT is one of the popular lossless image compression techniques for its simpler decoding structure and it can achieve high compression ratio, while maintaining [1]*

II. IMAGE COMPRESSION ALGORITHM

In Lossless compression algorithms reconstruct the exact version of original data from the compressed data whereas in lossy compression, [2] the reconstructed image data is approximate to the original image data. Lossless image compression is usually used in artificial images that contain sharp-edged lines such as technical drawings, textual graphics, comics, maps or logos and medical images. [2] Despite high quality of reconstructed image, lossless compression methods cannot achieve high compression ratio.



III. DISCRETE WAVELET TRANSFORM

Discrete Wavelet Transform adopts the fast algorithm of two dimensional images. The original image is decomposed into four sub-bands after passing a high- pass filter and low- pass filter [3]. The four sub-bands are LL, HL, LH and HH respectively. *LL is a low frequency sub-band of the approximate image. HL is a high frequency sub-band of the horizontal details of the image. LH is a high frequency sub-band of the vertical details of the image. HH is a high frequency sub-band of the diagonal details of the image.* The process is called the first level of wavelet decomposition. The low frequency sub-band can be continually decomposed into four sub-bands. *The decomposition can be infinitely repeated in theory.* But people must take the quality of the reconstructed image into consideration. Thus, people don't decompose image beyond the fifth level. Researchers usually use the third level. The model of wavelet decomposition of the third level is shown in Figure 1.

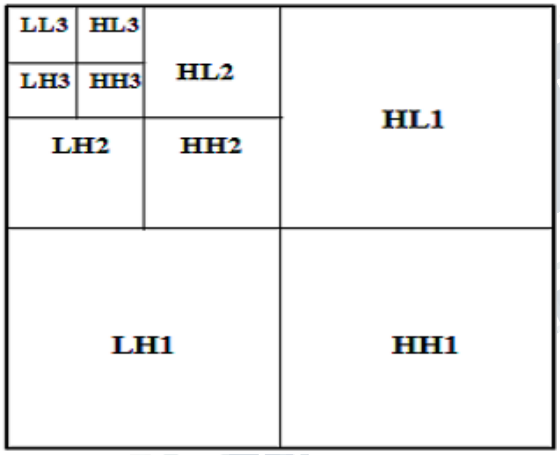


Fig.1 [3 Level wavelet decomposition]

IV. HUFFMAN ENCODING

Huffman encoding [4] is a lossless data compression technique for coding symbols based on their statistical occurrence frequencies (probabilities). The pixels in the image are treated as symbols and codes are assigned to symbols in such a way that symbols that occur most frequently take the shortest codes. [4] A unique prefix code is assigned to each unique symbol and thus compresses data by replacing each fixed-length input symbol by the corresponding variable length prefix codeword. The length of each codeword is approximately proportional to the negative logarithm of the probability. Therefore, shortest codes are assigned to most common symbols with highest probabilities and longer codes are assigned to symbols with low probabilities.

V. RESULT DISCUSSIONS

	Decomposition level								
	1				2				3
Wavelet	RMSE	PSNR	CR	SSIM	RMSE	PSNR	CR	SSIM	RMSE
HAAR	6.72	31.58	65.11	0.98	5.11	33.97	77.96	0.97	5.68
DB7	6.45	31.94	61.79	0.99	5.47	33.37	74.38	0.97	6.25
SYM4	6.51	31.86	63.61	0.99	5.33	33.6	76.29	0.97	5.98
BIOR_4.4	6.48	31.89	62.13	0.99	5.24	33.74	75.88	0.98	5.9
COIF2	6.52	31.84	62.49	0.99	5.33	33.59	74.94	0.97	5.98
RBIO 1.3	6.59	31.75	64.44	0.99	5.28	33.68	77.3	0.97	5.99

Table-1: Comparison of different Wavelet family for cameraman image

Figure : .1.Cameraman Image for CR=60.77, PSNR=31.88, MSE=6.4980, SSIM=0.9865 WAVELET FILTER= 'BIOR 6.8, DECOMPOSION EVEL=1"

Proposed work have performed the experiments and analyzed the result for wide range of wavelet families using different way just like (1) different decomposition level (2) different large range of wavelet families namely Dmey, Daubichies, Symlets, Coiflets, Haar, Biorthogonal, Reverse Biorthogonal for the evaluation of the test images

Cameraman (256x256) and Woman (256x256) with Thresholding value 35.

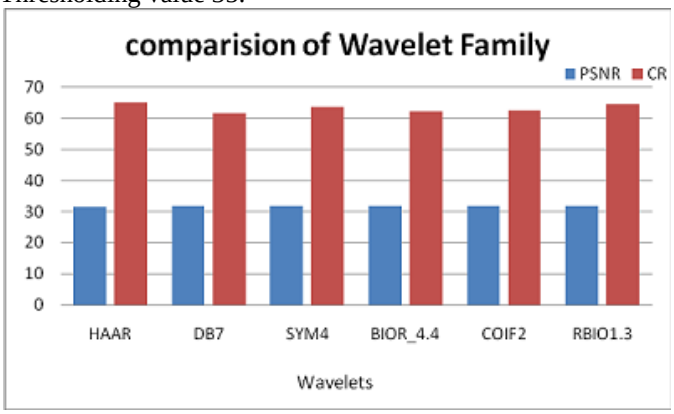


Figure: 2 Comparison of different Wavelet family for cameraman image

From Table-1,Figure 1 and Figure 2 it is found that higher the decomposition level which results higher compression ratio and RMSE, but the value of PSNR and SSIM get reduced. Also it is found that at all the of decomposition level DMEY give lowest CR and HAAR give higher CR but SSIM value is best for reverse biorthogonal wavelet as compared to other wavelets. As value of decomposition level and threshold increase, the quality of reconstructed image is decreased but CR is increased for both cameraman and woman test images. SSIM is the best parameter then MSE for analyzing the quality of reconstructed image. We used, Structural Similarity Index Measurement (SSIM) as the objective quality measure and Peak signal to noise ratio (PSNR) as the subjective quality measure. Therefore, conclusively we can say that RBIO1.3 is "best wavelet" in the image compression of images based on Compression Ratio and reconstructed image quality. For cameraman image decomposition level-1 and bior6.8 gives CR=60.77, PSNR=31.88, MSE=6.4980, SSIM= 0.9865, but for Woman image decomposition level-1 and bior6.8 gives CR=53.1605, PSNR=24.3862, RMSE=15.3897, SSIM=0.9514.

VI. CONCLUSION

This proposed research work presents an analysis and comparisons of wavelet families namely Biorthogonal, Daubechies, Coiflet and Symlets for image compression considering PSNR, CR, RMSE and visual quality of image on cameraman test image has been done and we have analyzed the result for wide range of wavelet families using different value of decomposition level After analysis of wavelet families using image compression and it is found that the biorthogonal wavelet provides best compression performance for cameraman image. As decomposition level increases, quality of reconstructed image will decreases but Compression ratio increases.

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