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Various DWT Algorithms for Monochrome image and Video

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Abstract*— *In this paper, transform based image and video coding is proposed. DCT is widely used for video coding. However, a DWT based algorithm is proposed in this work. DWT provides good localization both in time and frequency domain and it has high performance than DCT. The wavelet used in the proposed system is Daubechies, Bi-Orthogonal and symlet's which is applied for a Monochrome image of size 512x512. Video coding can be processed by using Haar wavelet. Multilevel decomposition is applied to images to achieve good compression. At each level, performance is analyzed based on compression ratio, PSNR, MSE and SSIM. The results show that, the proposed algorithm has the better performance and the reconstruction quality.

Keywords*— *Video compression, Discrete Wavelet Transform (DWT), Haar wavelet, Multi-level decomposition.

I. INTRODUCTION

Discrete wavelet transform is used for processing the image and video as well as computer graphics. DWT consists of two main categories such as convolution-based and lifting-based method. The input image is decomposed into multilevel DWT to achieve high compression ratio. The multilevel 2-D DWT on the other hand, being highly computation-intensive and memory-intensive, is implemented in very large scale integration (VLSI) system to meet the temporal requirement of real-time applications.

In Image compression, DWT algorithm is first applied on rows and then followed by columns. By means of interchanging the order of rows and columns, DWT algorithms iterates on column first then followed by rows [1]. Similarly, IDWT algorithm is also applied to columns followed by rows to complete the reconstruction of image. Although video is continuous in motion, it is normally a series of still images and changing fast enough and so video compression is similar to image compression. The method of compressing all the frames in a video known as Video compression. The paper consists of VIP TRAFFIC video which has 120 frames in it. Devendra et al. [7] uses DCT architecture for an energy and area efficient VLSI architecture of an HEVC-compliant. And proposed with the implementation of pipelining scheme in order to process all transform sizes at a minimum throughput of 2 pixel/cycle with zero-column skipping for improved throughput [7]. Basant et al. [8] derived a convolution-based generic architecture for the computation of three-level 2-D DWT based on Daubechies (Daub) as well as biorthogonal filters.

Basant et al. [8][9] suggested to use new data-access scheme for the computation of lifting two-dimensional (2-D) discrete wavelet transform (DWT) without using data transposition. The proposed transposition-free structure for lifting 2-D DWT can be derived by using systolic arrays. Yusong Hu et al. [10] propose new parallel lifting-based 2-D DWT architecture with high memory efficiency and short critical path.

II. DISCRETE WAVELET TRANSFORM

The wavelets can be sampled in discrete manner for the purpose of analyzing numerical and functional data. Discrete wavelet transform has the advantage of temporal resolution over Fourier transform and discrete cosine transforms by capturing on both frequency and time information. Wavelets can be efficiently used to analyze abrupt changes where in the former method it doesn't shows about the abrupt changes. Wavelets are designed to get good frequency resolution for average intensity of images and high temporal resolution for edges of images.

2.1 Image Compression

Image compression is the representation of an image in digital form with as few bits as possible while maintaining an acceptable level of image quality. Data compression is the technique to reduce the redundancies in data representation in order to decrease

data storage requirements and hence communication costs. Reducing the storage requirement is equivalent to increasing the capacity of the storage medium increase the speed of transmission and hence communication bandwidth.

- Lossless compression
- Lossy compression

2.2 Video Coding

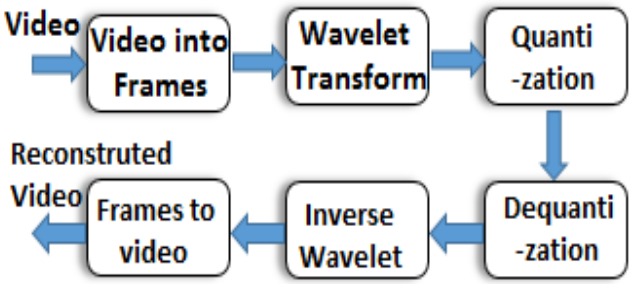

FIG. 2. SINGLE STAGE OF DWT

Original Videos are first converted into frames which show like a continuous of still images. Each frame in the video must be processed in order to get the high video quality. Each frame undergoes Haar wavelet transform as described. The compressed frame must be quantized. Quantization is a lossy compression technique which achieves compressing a range of values that can be rounded off to the single quantum value. When the number of discrete symbols in a given stream is reduced, the stream becomes more compressible. Ignoring high frequency components can reduce the information and then rounding to the nearest integer or set to zero.

III. PERFORMANCE METRICS

3.1 Compression ratio

The reduction in the size of data and space savings due to the compression is given by compression ratio [3].

$$\boldsymbol{Compression\ Ratio = Uncompressed\ Size\ / Compressed\ Size} \quad (1)$$

The compression ratio is used to measure the ability of data compression by comparing the size of the compressed frame to original frame [5].

3.2 Mean Square Error

MSE is the mean of squared error in the decompressed frame. It is the difference between the square of the original and the reconstructed image. Here, *X* and *Y* are the two compared images, the size of each being *M* × *N* pixels

$$\boldsymbol{MSE = {}^{1}/_{m \times n} \sum_{j=0}^{n-1} \sum_{i=0}^{m-1} [X(i,j) - Y(i,j)]^2} \quad (2)$$

3.3 Peak Signal-To-Noise Ratio

Peak signal-to-noise ratio is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is used to measure the quality of the reconstructed image [5].

$$\boldsymbol{PSNR = 20 * \log_{10}(255^2/MSE)} \quad (3)$$

3.4 Structural Similarity Index Matrix

SSIM index is a framework for quality assessment based on the degradation of structural information. The product of the illumination and the reflectance gives the luminance of the surface of an object. SSIM index defines the structural information in

an image as those attributes that represent the structure of objects in the scene, independent of the average luminance and contrast.

IV. EXPERIMENTAL RESULT

4.1 Simulation Result for a Monochrome image

The input image given for this process has the size of 512X512. Daubechies, Bi-Orthogonal and symlet wavelet' s is applied to the input image.

FIG. 3. THREE LEVEL DECOMPOSITION FOR db, BI-ORTHO, SYMLET WAVELET

Three level decomposition for each wavelet is completed. From the figure 3, it infers that the wavelet transform decomposes the image into low-low, low-high, high-low and high-high frequency components. These four components are referred to as approximation, horizontal, vertical and diagonal coefficients respectively because low-low frequency components contain average information whereas the other components contain directional information due to spatial resolution.

4.2 Comparison of Various Wavelets for image

From the table 1, it inferred that Orthogonal(Daubechies) and Bi-Orthogonal tends to have higher gain and lesser error compared to that of symlet wavelet. So, in the succeeding work for implementation of video by Daubechies and Bi-Orthogonal can be used to get a better result.

TABLE 1
COMPARISON TABLE FOR IMAGE QUALITY METRICS

S.NO	*IMAGE SIZE*	*WAVELET*	*MSE*	*PSNR*	*COMPUTATION TIME(s)*	*SSIM*
1	512x512	Orthogonal	0.4293	57.8578	3.5156	0.8883
2	512x512	Bi-Orthogonal	0.3852	58.3119	2.4531	0.8883
3	512x512	Symlet	0.3556	52.6207	2.6875	0.8883

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4.3 Video Coding

First, convert the video into the sequence of the image frames, the number of frames depends on duration of video sequences. Hockey.avi and Rhinous.avi file is used for a video compression. Compression Process can be carried out by using Haar Wavelet. The Compressed image frames can be further processed by the use of Inverse Discrete wavelet Transform. The Decompressed image frames can be shown in Figure 3 and Figure 4.

Frame 1 **Frame 25** **Frame 50** **Frame 77**

FIG .3 DECOMPRESSED VIDEO FRAME(HOCKEY)

Several quality metrics discussed in section (CR, *MSE, PSNR, SSIM*) was used to examine the quality of the compression results. We underwent our proposed algorithm in MATLAB2014b Quality metrics corresponding to the compression results of figure 3 and figure 4 is tabulated in TABLE 2. From the table, we infer that the compressed image shows better results when Haar wavelet is applied. Compression Ratio obtained for both examples are 64.

Frame 1 **Frame 25** **Frame 50** **Frame 77**

FIG.4. DECOMPRESSED VIDEO FRAME (RHINOS)

It shows best results with low MSE and high PSNR and also with other evaluation metrics (*CR, SSIM*) proving that the proposed technique works well in image compression.

TABLE 2
PERFORMANCE METRICS

Quality Metrics	MSE		PSNR		SSIM
Frames	*Hockey*	*Rhinos*	*Hockey*	*Rhinos*	*Both*
1	0.4790	0.5626	54.5245	53.1269	1
8	0.4784	0.5628	54.5348	53.1276	1
24	0.4784	0.5627	54.5342	53.1247	1
60	0.4790	0.5617	54.5238	53.1403	1
77	0.4789	0.5614	54.5252	53.1449	1

V. CONCLUSION

Image and Video compression plays major role in multimedia and communication systems whereas redundant data can be removed without affecting the information content of the image. This paper details with the analysis of various wavelets. Further extension in series of color image (video) comprises of wavelet decomposition to achieve reasonable compression ratio and PSNR. The quality measurement of the compressed images (CR, MSE, PSNR, SSIM) have been presented here for monochrome image. DWT based experiment shows the better performance compared with DCT. Implementation of video coding for color image is proposed to be done in future also by using different wavelets like Orthogonal and Bi-orthogonal wavelet filter.

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