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Performance Analysis of Image and Video Coding by Wavelet Transform using Region of Interest

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Abstract-

In this paper we present image and video compression using embedded zerotree wavelet algorithm on different wavelet filters such as haar, daubechies, biorthogonal . To achieve better compression ratio as needed in low bandwidth network we use region of interest(ROI) technique so that data which is not important to us i.e., non ROI(background) can be compressed to much higher compression rate as compared to ROI which is important region for us. ROI is a technique to represent the important area and background in an efficient manner so that the important area in the image can be reconstructed even at low bit rates at the compromise of background.

Keywords-Wavelet Transform , Image Compression, Video Compression, Embedded zerotree wavelet, ROI.

I. INTRODUCTION

From last few decays, the increasing demand of storage and transmission of multimedia, becomes an inseparable part of day to day life. Image and video are the most important media contributing to multimedia[1]. Thus, we need data to be in compressed form . So, that it can be transmitted over network easily if also we have a limited bandwidth. Discrete wavelet transformations (DWT) followed by embedded zero tree encoding is a very efficient technique for image and video compression[2]. J.M. Shapiro developed the embedded zero tree wavelet algorithm in [3] which yields a fully embedded code and consistent compression. With embedded encoding, we can recover the lossy version with distortion corresponding to the rate of the received image at the point of decoding process[4]. This paper proposes a technique of image and video compression using embedded zerotree wavelet compression which includes region of interest coding i.e., ROI-EZW(Region of interest-Embedded Zerotree coding) thereby data can be transmitted over low bandwidth network easily with important data has been processed first. ROI is a technique to represent the important area and background in an efficient manner so that the important area in the image can be reconstructed even at low bit rates at the compromise of background. This paper is organized as follows, Section II discuss about discrete wavelet transform. Section III includes a brief description of embedded zerotree wavelet. Section IV discuss about the region of interest(ROI) and the technique used. In section V we proposed our technique for compression. Section VI contains result and discussion and section VII contains the conclusion.

II. DISCRETE WAVELET TRANSFORM

Wavelets[12] are functions that satisfy certain requirements. The very name wavelet comes from the requirement that they should integrate to zero, “waving” above and below the x-axis. Wavelet transform (WT) represents an image as a sum often wavelet functions (wavelets) with different locations and scales[14,15]. The diminutive connotation of wavelet suggests the function has to be well localized. Other requirements are technical and needed mostly to insure quick and easy calculation of the direct and inverse wavelet transform. The wavelet decomposes the image, and generates four different horizontal frequencies and vertical frequencies outputs[13].Wavelets are maily divided into two categories orthogonal an biorthogonal wavelet filters.

Wavelet function

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}}\psi(\frac{t-b}{a})$$

$$\Psi_{a,\,b_x,\,b_y}(x,y) = \frac{1}{|a|}\Psi\left(\frac{x-b_x}{a},\frac{y-b_y}{a}\right)$$ **2D function**

where a is scale coefficient and b is shift coefficient.

(A) The DWT of an Image

The procedure for decomposition of the image is as follows [16]. A low pass filter and a high pass filter are chosen, such that they exactly halve the frequency range between themselves. This filter pair is called the Analysis Filter pair. First, the low pass filter is applied for each row of data, thereby getting the low frequency components of the row. But since the lpf is a half band filter, the output data contains frequencies only in the first half of the original frequency range. So, by Shannon's Sampling Theorem, they can be sub sampled by two, so that the output data now contains only half the original number of samples. Now, the high pass filter is applied for the same row of data, and similarly the high pass components are separated, and placed by the side of the low pass components. The same is repeated for all rows. Next, the filtering is done for each column of the intermediate data. The resulting two-dimensional array of coefficients contains four bands of data, each labelled as LL (low-low), HL (high-low), LH (low-high) and HH (high-high). The LL band can be decomposed once again in the same manner, thereby producing even more sub bands. This can be done up to any level, which results in a pyramidal decomposition shown in Figure.

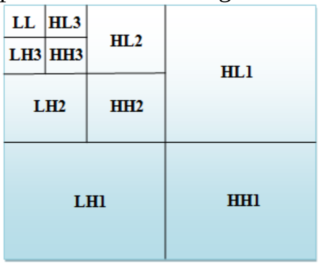


Fig.2 Pyramidal structure of a wavelet decomposition

The LL band at the highest level can be classified as most important, and the other 'detail' bands can be classified as of lesser importance, with the degree of importance decreasing from the top of the pyramid to the bands at the bottom.

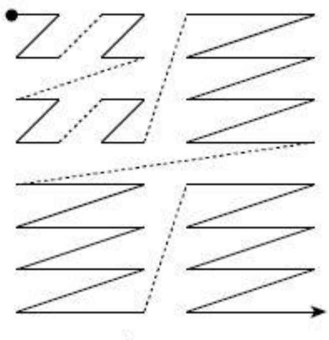
(B) DWT of Video

Wavelets concentrate speech signals into a few neighbouring coefficients.[5] By taking the wavelet transform of a signal, many of its coefficients will either be zero or have negligible magnitudes. Data compression can then be done by treating the small valued coefficients as insignificant data and discarding them. Compressing a speech signal using wavelets involves the following stages.

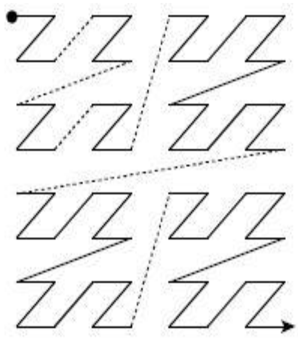
III. EMBEDDED ZEROTREE WAVELET

In 1992 Marc Antonin describes the image coding[5] using wavelet transform that taking into account both space and frequency domain. To encode the coefficients of a noise shaping bit allocation procedure has been used by the author that details that at high resolution less frequencies are visible to human eye. But this encoding technique is not much efficient. J Shapiro[1993] proposed the Embedded Zerotree Wavelet algorithm[6] for encoding which generated the bitstream in order of importance, yielding a fully embedded code. EZW produces compression result which gives a tough competition to virtually known compression algorithms. Embedded coding is also called progressive coding which means that as more bits are added to the stream, the decoded image will contain more detail. Zerotree is a concept in which a concise encoding of the positions of significant values can be seen during the embedded coding process.

Zerotree is a quadtree having some significant and insignificant values at each locations for an initial threshold T_0, which gets halved after each pass. This tree has node which are equal , less or greater than the root node. Zerotree is based on the preassumption that if a wavelet coefficient at a coarse scale is insignificant with respect to a given threshold then all wavelet coefficients are likely to be insignificant with respect to the threshold T_0. EZW encoder encodes the so obtained tree structure. Thus result[7] is bits that are generated in order of importance , leading to a fully embedded code. The process is repeated after lowering[7] the threshold, until threshold become smaller than the smallest coefficient to be transmitted. Generally we use two scanning order for scanning codes which are morton scaning technique and rastar scanning technique.



Rastar scan



Morton scan

EZW Algorithm[2]:

1. Initialise initial threshold,

$$T = 2\lfloor \log_2(max(|\gamma(x,y)|))\rfloor$$

2. threshold = initial_threshold;

```
do {
 dominant_pass(image);
 subordinate_pass(image);
 threshold = threshold/2;
} while (threshold>minimum_threshold);
```

```
3. /* Dominant pass */
        initialize_fifo();
        while (fifo_not_empty) {
         get_coded_coefficient_from_fifo();
         if coefficient was coded as P, N or Z then {
         code_next_scan_coefficient();
        put_coded_coefficient_in_fifo();
         if coefficient was coded as P or N then {
         add abs(coefficient) to subordinate list;
         set coefficient position to zero;
         }
        } }
4. After dominant pass
   /* Subordinate pass */
   subordinate_threshold = current_threshold/2;
   for all elements on subordinate list do {
    if coefficient>subordinate_threshold then {
   output a one;
    coefficient = coefficient-subordinate_threshold;
   }
    else output a zero;
}
```

IV. REGION OF INTEREST

A region of interest (often abbreviated ROI), is a selected subspace within a dataset analyzed for a particular purpose[8]. The concept of a ROI is commonly used in many application areas. The basic goal of region of interest (ROI) based compression for medical image is to enhance the compression efficiency for transmission and storage[9].The ROI coding is based on the scaling of wavelet coefficient. The basic concept behind the scaling based method is to scale up the coefficients of ROI so that ROI bits are placed in higher bit planes. Then during embedded encoding process bits having higher coefficient values (ROI bits) are placed in the bit stream before the background (non-ROI) parts of the image[10]. Thus, the ROI will be processed before the non ROI part of the image.

The limitations posed by scaling based methods are overcome in another ROI encoding approach, known as the MAXSHIFT. an entire volumetric image is transformed and only the coefficients associated with the ROI are scaled up through a given number of bit-shifts, where the number of bit-shifts, which is called scaling value *s*, is given by the largest number of non-empty magnitude bit-planes of the coefficients[1]. Instead of specifying the desired scaling value as in the previous method, the encoder scans the quantized coefficients and chooses a scaling value such that the minimum coefficient magnitude belonging to the ROI is larger than the maximum coefficient magnitude in the background[10]

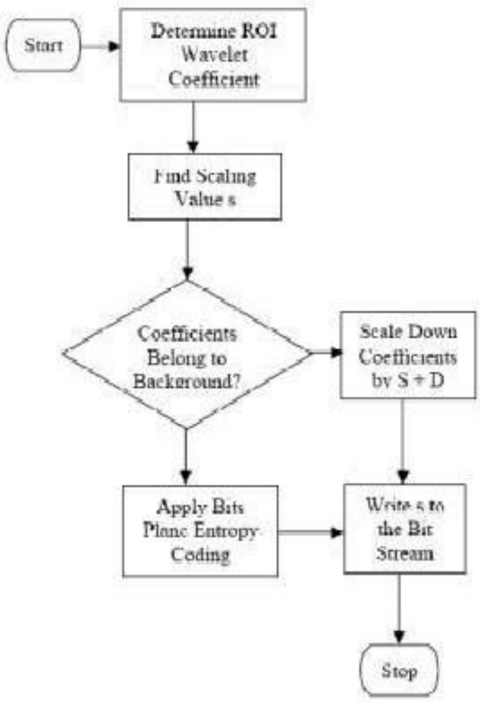


Fig 4.1: Maxshift Technique[].

V. PROPOSED TECHNIQUE FOR COMPRESSION

We develop a technique for image and video compression technique which uses embedded zerotree wavelet transform with region of interest technique and analyze its performance on haar, daubechies and biorthogonal wavelet filter. Using region of interest technique with embedded zerotree algorithm gives us a fully embedded code in which important wavelet coefficient which is region of interest has been processed first leading to background region to be processed last. In addition to this data compressed by our technique can be easily sent over a network having low bandwidth as the bits of background region of interest area is highly compressed.

Proposed Algorithm:

Step 1. Input image, decomposition_level, Shifting_parameter
Step 2. from 1 to decomposition_level
Step 3. Decompose(image)
Step 4. goto 2
Step 5. Select ROI
Step 6. if dim(ROI)>dim(image)
Step 7.goto step 18
Step 8.else goto 9
Step 9.Mask ROI to wavelet domain
Step 10. Choose ROI_Scale
Step 11. if min_ROI_coeff > Max_background_coeff
Step 12. ROI_scale=min(2^Shifiting_parameter)
Step 13. else goto 11
Step 14 .Downscale (background_coefficients)
Step 15. Embedded_encoding(ROI_cofficient+background_coefficient)
Step 16. Reconstruct(image) // decoder's end.
Step 17. Upscale (background_coefficient)
Step 18. Calculate MSE(Mean squared Error)
Step 19. Calculate PSNR(Peak Signal to Noise Ratio)
Step 18. end

VI. RESULT AND DISCUSSION

Simulation parameters

1. PSNR (Packet Signal to Noise Ratio): It is Defined as the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale[2].High PSNR indicates high quality reconstruction.

PSNR (in dB) is defined as:

MSE = (1/(m*n))*sum(sum((f-g).^2))

PSNR = 20*log(max(max(f)))/((MSE)^0.5)

Where f is reconstructed image and g is original image.

2. Bitrate: Bitrate, as the name implies, describes the rate at which bits are transferred from one location to another. In other words, it measures how much data is transmitted in a given amount of time. It is measured in bit per pixel.

Wavelet families can be classified into two main categories orthogonal and biorthogonal. Wavelet filters. We provide the result using both wavelet filters biorthogonal, haar, daubechies wavelet filters on image lenna 256X256 and video of avi format.

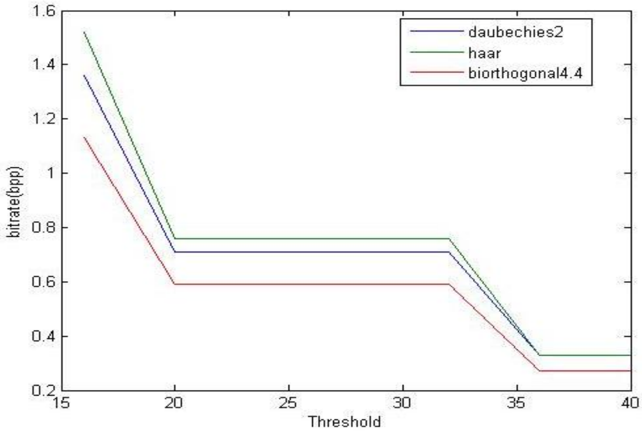


Fig. 6.1: Bitrate vs Threshold for Lena 256X256

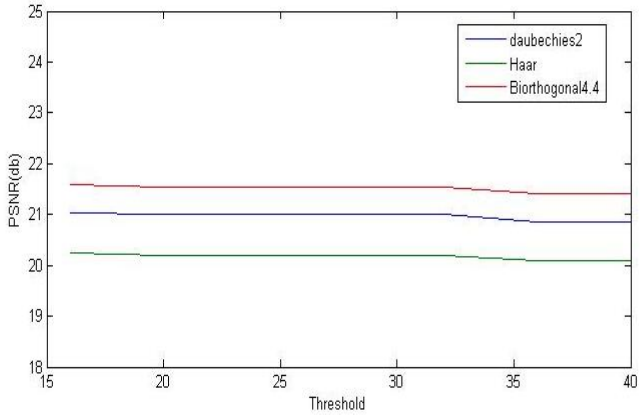


Fig.6.2: PSNR Vs Threshold for Lena 256X256

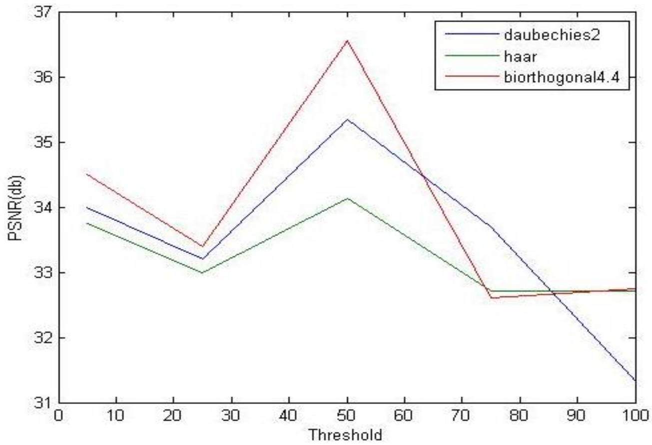


Fig.6.2: PSNR Vs Threshold for Mauka Video

Number of decomposition levels are fixed for every result. No. Of decomposition levels=8

IV. CONCLUSION

In this paper we proposed a new technique for image and video compression using EZW algorithm and using region of interest technique. The proposed compression techniques considerably improve the time performance of the system. Also the proposed Compression technique is simple and computationally less complex. Region of Interest technique is also compressed images and video to such level so that it can be transmitted over low bandwidth network. Simulation result shows that biorthogonal 4.4 wavelet filter shows obtain a better PSNR result at the cost of more computation.

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