ENTROPIES BASED IMAGE COMPRESSION USING WAVLET TRANSFORMATION

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Abstract

DWT has high decorrelation and energy compaction efficiency. The blocking artifacts and mosquito noise are absent in a wavelet-based coder due to the overlapping basis functions.. This paper aims to investigate the performance of wavelet tree based image compression system based on various entropies. In wavelet packet tree based compression system, compression is done by using various entropies. In this paper an image is compressed using these different entropies and their results are compared to select the best entropy for the given image. Also performance of wavelet packet tree based image compression system and discrete wavelet transform based compression system are compared. The test results indicate that wavelet packet tree based image compression system shows good performance as compared to discrete wavelet transform compression system.

Keywords: *Wavelet, Wavelet Packet Tree, Shannon, Threshold, Norm, Log energy Entropy*

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1. INTRODUCTION

The international standard organization (ISO) has proposed the JPEG standard[1] for image compression. These standards employ discrete cosines transform (DCT) to reduce the spatial redundancy presented in images. It is noted that DCT has drawbacks of the blocking artifacts, mosquito noise and aliasing distortions at high compression ratio[2].

Discrete Wavelet Transform (DWT) has emerged as a popular technique for image coding applications. DWT has high decorrelation and energy compaction efficiency. The blocking artifacts and mosquito noise are absent in a wavelet-based coder due to the overlapping basis functions. The JPEG 2000 standard employs a discrete wavelet transform for image compression due to its merits in terms of scalability, localization and energy concentration [3].

The performance of discrete wavelet transform based coding depends on the wavelet decomposition structure. In wavelet decomposition, the approximate component of image is further decomposed, but in wavelet the approximation as well as detailed components are decomposed. In this paper we will investigate the performance of wavelet packet tree based image compression system by using different entropy-based criterion.
In case of discrete wavelet, the image is decomposed into a discrete set of wavelet coefficients using an orthogonal set of basis functions. These sets are divided into four parts such as approximation, horizontal details, vertical details and diagonal details.

2. ENTROPIES AND ITS TYPE

There are a number of entropy-related concepts that mathematically quantify information content in some way:

- the self-information of an individual message or symbol taken from a given probability distribution,
- the entropy of a given probability distribution of messages or symbols, and
- The entropy rat**e** of a stochastic process.

(The "rate of self-information" can also be defined for a particular sequence of messages or symbols generated by a given stochastic process: this will always be equal to the entropy rate in the case of a stationary process.) Other quantities of information are also used to compare or relate different sources of information. It is important not to confuse the above concepts. Oftentimes it is only clear from context which one is meant. For example, when someone says that the "entropy" of the English language is about 1.5 bits per character, they are actually modeling the English language as a stochastic process and talking about its entropy rate. Although entropy is often used as a characterization of the information content of a data source, this information content is not absolute: it depends crucially on the probabilistic model. A source that always generates the same symbol has an entropy rate of 0, but the definition of what a symbol is depends on the alphabet. Consider a source that produces the string ABABABABAB... in which A is always followed by B and vice versa. If the probabilistic model considers individual letters as independent, the entropy rate of the sequence is 1 bit per character. But if the sequence is considered as "AB AB AB AB AB..." with symbols as two-character blocks, then the entropy rate is 0 bits per character.

Shannon entropy:- The Shannon entropy satisfies the following properties, for some of which it is useful to interpret entropy as the amount of information learned (or uncertainty eliminated) by revealing the value of a random variable *X*. Adding or removing an event with probability zero does not contribute to the entropy:

$H_{n+1}(P_1, P_2\ldots\ldots\ldots\ldots, P_n, 0) = H_n(P_1, P_2\ldots\ldots\ldots\ldots, P_n)$. It can be confirmed using the Jensen inequality that

$$H(X) = E\left(\log_b\left(1/P(X)\right)\right) \leq \log_b\left(E\left(1/P(X)\right)\right) = \log_b(n)$$

3. ENERGY RETAINED

When compressing with orthogonal wavelets the energy retained is :

$$\frac{100\ (\text{vector norm(coeffs\_ of \_ the \_ current\_decomposition,2)})^2}{\text{vector norm(original \_ signal,2)})^2}$$

4. IMAGE COMPRESSED USING DWT

Compression is achieved by reducing or removing redundancy. The redundancy of an image is caused by the correlation between pixels, so transforming the pixels to a representation where they are decorrelated eliminates the redundancy. It is also possible to think of a transform in terms of the entropy of the image. In a highly correlated image, the pixels tend to have equiprobable values, which results in maximum entropy. If the transformed pixels are decorrelated, certain pixel values become common, thereby having large probabilities, while others are rare. This results in small entropy. Quantizing the transformed values can produce efficient lossy image compression. Wavelet transforms have received significant attention because their multi resolution decomposition allows efficient image analysis.

Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other functions. The basic idea of the wavelet transform is to represent any arbitrary signal 'X' as a superposition of a set of such wavelets or basis functions. These basis functions are obtained from a single photo type wavelet called the mother wavelet by dilation (scaling) and translation (shifts). The discrete wavelet transform for two dimensional signal can be defined as follows.

$$x(a1,a2,b1,b2,) = 1/\sqrt{a_1 a_2} * \Psi\left(X\text{-}b_1/a_1\ ,\ X\text{-}b_2/a_2\right)$$

The indexes w(a1,a2,b1,b2,) are called wavelet coefficients of signal X, and a1,a2 are dilation and b1,b2 is translation Ψ, is the transforming function, which is known as mother wavelet. Low frequencies are examined with low temporal resolution while high frequencies with more temporal resolution. A wavelet transform combines both low pass and high pass filtering in spectral decomposition of signals.

In case of discrete wavelet, the image is decomposed into a discrete set of wavelet coefficients using an orthogonal set of basis functions. These sets are divided into four parts such as approximation, horizontal details, vertical details and diagonal details.

5. IMAGE COMPRESSED USING WAVLET PACKET TREE

The wavelet packet method is a generalization of wavelet decomposition that offers a richer range of possibilities for signal analysis. In wavelet analysis, a image is split into an approximation and a detail. The approximation is then itself split into a second-level approximation and detail, and the process is repeated.In wavelet packet analysis, the details as well as the approximations can be split. This yields more than different ways to encode the image. This is the wavelet packet decomposition tree.

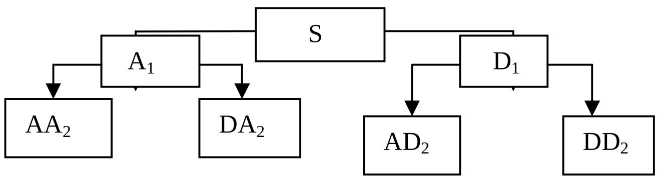


Fig. 3.wavelet packet decomposition tree

The wavelet decomposition tree is a part of this complete binary tree. For instance, wavelet packet analysis allows the signal S to be represented as A1 + AAD3 + DAD3 + DD2. This is an example of a representation that is not possible with ordinary wavelet analysis. Choosing one out of all these possible encodings uses an entropy-based criterion to select the most suitable decomposition of a given image.
This means we look at each node of the decomposition tree and quantify the information to be gained by performing each split. Simple and efficient algorithms exist for both wavelet packet decomposition and optimal decomposition selection. clipping methods, peak windowing schemes attempt to minimize the out

of band radiation by using narrowband windows such as Gaussian window to attenuate peak signal.

6. EXPERIMENTAL RESULTS

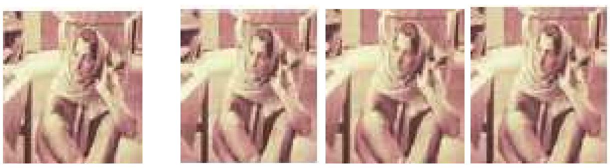
In this paper results of compression are compared in terms of percentage of zeros, percentage of energy retained and Root Mean Square Error. Root Mean Square Error (RMSE) is square root of the cumulative squared error between the compressed and the original image. The mathematical formulae for the RMSE is:

Error E = Original image – Reconstructed image …………..i
RMSE = sqrt[E / (SIZE OF IMAGE)]………………………..ii

A lower value for RMSE means lesser error. The energy retained describes the amount of image detail that has been kept; it is a measure of the quality of the image after compression. The number of zeros is a measure of compression. A greater percentage of zeros implies that higher compression rates can be obtained. So, a compression scheme having a lower RMSE, higher percentage of zeros and higher percentage of energy retained can be recognized as a betterone.
To select the best entropy in wavelet packet tree based image compression system, we performed the compression on image wbarb using different entropies. Fig. 4 (a) shows the original wbarb and Fig. 4(b) ,4(c), 4(d), shows results of compressed image using Shannon, threshold, norm, log energy and sure entropy. Table1 shows the results of using various types of entropy for image wbarb.

Then to compare the wavelet packet tree and discrete wavelet transform based compression systems we performed.the compression on standard 256*256 color images : leena, woman, wbarb, trees and julia constructed images using the wavelet packet tree and discrete wavelet transform based compression systems. Results are observed in terms of percentage of zeros, percentage of energy retained and Root Mean Square Error. Fig. 5(a) shows the original image and Fig.5(b), Fig.5(c) shows the compressed image using wavelet decomposition and wavelet packet best tree respectively for the image woman. Table2 shows the results of discrete wavelet transform and Table3 shows the result of wavelet packet best tree for different images.

Original image



(a) (b) (c) (d)

Fig.4. Original wbarb image and its results.

Original image

(a) (b) (c)

Fig. 5 original woman image and its results

Type of entropy	Percentage of zeros	Percentage of energy retained
threshold	85.70	99.54
norm	86.12	99.54
Log energy	85.74	99.55

Table1:Results of using different types of entropies in wavelet packet best tree for image wbarb.

Name of the images	Global threshold value	Percentage of zeros	Percentage of energy retained
Leena	57.25	98.59	98.59
women	87	97.20	97.20
wbarb	73.63	97.72	97.72
trees	62.25	97.33	97.33
Julia	26	95.76	95.79

Table2: Results of Discrete Wavelet Transform

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Name of the images	Global threshold value	Percentage of zeros	Percentage of energy retained
Leena	57.44	98.59	98.59
women	87	97.49	97.49
wbarb	76.81	97.81	97.81
trees	63.5	97.34	97.34
Julia	26	95.76	95.79

Table3: Results of wavelet packet best tree

CONCLUSION

Results of compressing the image using the various entropies in wavelet packet tree representation in Table1 shows that log normal entropy is best for the image wbarb as it gives highest percentage of zeros and highest percentage of energy retained. Also mean square error is minimum as compared to other entropies. Results of compressing the image using the discrete wavelet transform and wavelet packet best tree in Table2 and Table3 respectively shows that the number of zeros and energy retained in wavelet packet best tree representation is higher as compared to discrete wavelet transform representation even when the threshold value for wavelet packet tree compression is higher. This illustrates the superiority of wavelet packets for performing compression requirements for The PAPR reduction should be minimal.

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