COLOR IMAGE COMPRESSION USING WAVELETS

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***Abstract*— A problem in evaluating the picture quality of an image compression system is in describing the amount of degradation in reconstructed image, Wavelet transforms which are set of mathematical functions in image compression applications owing to the computational simplicity that comes in the form of filter bank implementation. Here the method presents a new lossless color image compression algorithm, based on the hierarchical prediction of pixels and Wavelet Coding. A hierarchical scheme is developed that enables the use of upper, left, lower pixels for the pixel prediction, whereas the conventional raster scan prediction methods use upper and left pixels. A context model for the prediction error is also defined and daubechies wavelet transform and symlet wavelet transform is applied to the error signal corresponding to each context. The Proposed work is carried by the application of hand designed wavelet family like daubechies and symlets on a variety of images**

***Index Terms*— Hierarchical prediction, Lossless color image compression, Reversible color transform, Wavelet Coding.**

I. INTRODUCTION

Image compression can be defined in a simple manner as an application of data compression that minimizes the size of the original image without resulting in the degradation of image quality. The principal approach in data compression is the reduction in the amount of image data (the number of bytes) while preserving information (image details). Hence, image compression aims to reduce both the *irrelevance* and the *redundancy* available in the image data with the intention of optimizing and putting to maximum use the data storage and data transmission facilities. Here, the irrelevancy reduction implies that the information removed in this process is systematically selected such that it includes data irrelevant to the user.

Image compression is one of the most visible applications of wavelet transforms additional to diversified fields as biomedical applications, wireless communications. [1]Wavelet based image coders like JPEG2000 standard easily outperform the traditional discrete cosine transform based JPEG image compression.

Wavelet analysis is about analyzing signal with short duration energy functions. The transformation of the signal is called wavelet transform. It does not change the information content present in the signal. This transform can be used to analyze non-stationary signals.Wavelets provide good compression ratios for high resolution images and perform better than competing technologies like JPEG, in terms of signal to noise ratio and visual quality [4]. Unlike JPEG, wavelets show no blocking affects but allows for a degradation of the image quality while preserving the significant details of the image. In JPEG2000 standard image compression system the entire image is transformed and compressed as a single data object rather than block by block as in a DCT based compression system there by allowing uniform distribution of the compression error across the entire image to provide better image quality and high compression ratio[3].

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II. IMAGE COMPRESSION SYSTEM

Image compression techniques are broadly classified as lossy compression techniques and lossless compression techniques, depending on whether or not an exact replica of the original image could be constructed using the compressed image.

Lossless image compression techniques are limited in terms of compression ratios, they encode data exactly such that decoded image is identical to the original image. Lossless image compression is the only acceptable amount of data reduction. It provides low compression ratio while compared to lossy. In Lossless image compression techniques are composed of two relatively independent operations: (1) Devising an alternative representation of the image in which its inter-pixel redundancies are reduced and (2) coding the representation to eliminate coding redundancies.

Lossless compression uses predictive encoding which uses the gray level of each pixel to predict the gray value of its right neighbor, the overall result is the reduction of redundancy in the data. Lossless image compression techniques are mainly preferred for applications with stringent requirements such as medical imaging and diagnosis etc.

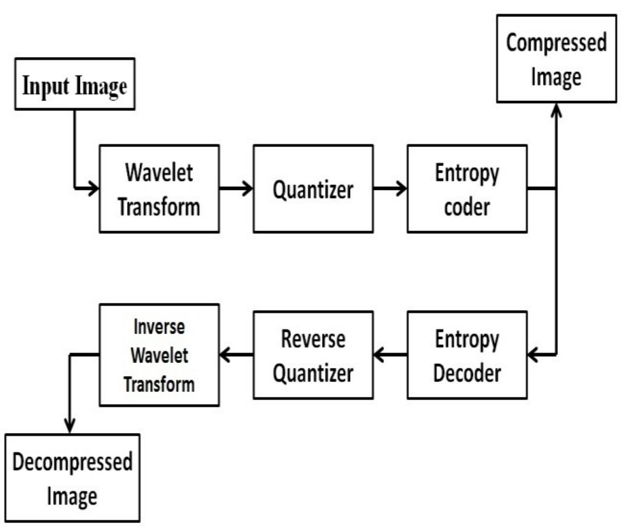

Fig 1: Transform based image compression system

III. PROPOSED METHOD

For the compression of color images, the color components are first de-correlated by a color transform, each of the transformed components is independently compressed. For example, the RGB to $Y\ C_bC_r$ transform may be the most frequently used one for the lossy compression of color image .In the case of lossless compression, most color transforms cannot be used due to their un-invertibility with integer hence an invertible version of color transform, the reversible color transform (RCT) was defined.

After the transformation of RGB to $Y\ C_uC_v$ by an RCT the Y channel is encoded by a conventional grayscale image compression algorithm. In the case of chrominance channels (C_u and C_v), the signal variation is generally much smaller than that of RGB, but still will be large near the edges. For more accurate prediction of these signals, and for accurate modeling of prediction errors, the hierarchical scheme is used: the chrominance image is decomposed into two sub images; i.e. a set of even numbered rows and a set of odd numbered rows respectively. Once the even row sub image X_e is encoded, we can use all the pixels in X_e for the prediction of a pixel in the odd row sub image X_o. In addition, since the statistical properties of two sub images are not much different, the pdf of prediction errors of a sub image can be accurately modeled from the other one, contributes to better context modeling for Wavelet coding [5].

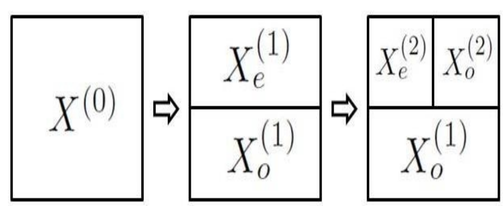

Fig 2: Hierarchical decomposition.

The efficiency of lossless compression based on the estimation of the pdf of the

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prediction error. For the compression of Xo pixels using Xe, directional prediction is employed to avoid large prediction errors near the edges.for each pixel xo(I,j) in Xo, the horizontal prediction x^h(I,j) and vertical predictor x^v(i,j) are defined as

$$\hat{x}_h (i, j) = x_o(i, j-1)$$

$$\hat{x}_0 (i,j) = round\left(\frac{x_e(i,j) + x_e(i+1,j)}{2}\right)$$

One of them is selected as a predictor for Xo (i,j).With these possible predictors, the most common approach to encoding is " mode selection" where the predictor of each pixel is selected and the mode is also transmitted as side information. A variable is defined for the direction of edge at each pixel dir(i,j) ,which is given either H or V .Mode selection is tried when more than one of dir(i-1,j) or dir(i,j-1) are H and the vertical prediction is performed for the rest.

For the efficient compression, the statistics of symbols (prediction errors) should well be described by an appropriate model and/or parameters. We model the prediction error as a random variable with pdf$P(e|Cn)$, where $Cn$is the coding context that reflects the magnitude of edges and textures. Specifically, $Cn$is the level of quantization steps of pixel activity $\sigma(i, j)$ defined as

$$\sigma (i, j) = |x_e(i,j) - x_e(i+1,j)|$$

Note that the local activity and its quantization steps are calculated with the pixels in X_e, because all the pixels of X_e are available and its statistical property would be almost the same as that of Xo. The local activity is quantized into K steps such that C_n represents the step

$$(i,j) < q_n$$

For $n = 1, \ldots, K$ with $q_0 = 0$ and $q_K = \infty$. The length of quantization steps is determined such that each step includes the same number of elements (local activities). For each context, a generic adaptive arithmetic coder [12] is used to encode the prediction error. For illustration, Fig. 3 shows an input image, the local activity of a sub image (context), and $P(e|Cn)$ for several Cn. It describes the statistical property of prediction error very well, in that the error magnitude is large when the local activity is strong. Hence the proposed model is strong with wavelet coding.

The Context is taken as the input of daubechies wavelet transform, which are again divided in to LL,LH,HL,HH sub images[2].LL sub image is having more information than the remaining sub images hence, LL sub image is taken into consideration and daubechies wavelet transform is applied. The output obtained is having design metrics such as mean square error(MSE),peak signal to noise ratio(PSNR) and compression ratio(CR)[6].The same procedure is again applied on the symlet wavelet transform and the standards are evaluated.

IV. RESULTS

In the proposed work, different color images and grayscale images with varying content of details are considered with decomposition using hand design wavelet family like haar wavelet transform.Metrics PSNR, CR and MSE so obtained are tabulated in Table I for analysis after simulation in Matlab environment.

Table I: Quality Metrics for Symlets

Image (128x128)	PSNR	CR	MSE
Lena	11.8211	21.5017	4.1902
Mandrill	10.3334	9.1672	6.2617
Barbara	11.9042	26.1271	4.1933
Endoscope	16.0378	26.4924	1.6192

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Image (128x128)	PSNR	CR	MSE
Lena	11.8376	21.5017	4.1902
Mandrill	10.1226	9.1672	6.2617
Barbara	11.8915	26.1271	4.1933
Endoscope	13.048	21.2875	1.5291

Table II: Quality Metrics for Daubechies

V. CONCLUSIONS

The Proposed method is based on a hierarchical prediction of pixels .For the compression of an RGB image, it is first transformed into $Y\ C_uC_v$ color space using an RCT. After the color transformation, the luminance channel Y is compressed by a conventional lossless image coder. Pixels in chrominance channels are predicted by the hierarchical decomposition and directional prediction. Finally Daubechies and Symlet wavelet transform are applied to the context image. This method is tested on different images. The results that are obtained clearly indicate that these two compression techniques offer good compression performance; it can be concluded that compression performance depends on the size and content of the image therefore it is appropriate to tailor the choice of wavelet based on image size and content for desired quality of reconstructed image.

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