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A Combined Method for CFA Image Compression with Haar Wavelet and GPPM Tree

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Abstract*— GPPM (Generic Peano Pattern mask tree) tree is a data mining data structure which can be used in the compression of CFA (color Filter Array) images. A novel compression method using Haar wavelet transform and GPPM tree is introduced in this paper. For a single dimensional array of pixels average of two successive values are taken as the low pass filter coefficients and differences between the pixel value and the average are taken as the detail coefficients in Haar transform. When averaged, the highest possible value is 255 since the maximum pixel value in the CFA image is 255. The least possible value in the detail coefficient value is -255 (0-255). Haar wavelet of the CFA image is taken and rounded first for the image. Then the positive and negative values are encoded. GPPM tree is applied for compression. Since the Haar transform is rounded the method is near lossless method. Compression ratio is used as a metric to compare the compression.

***Index Terms*— CFA image compression, GPPM tree, Haar wavelet, , near lossless compression, PPM tree.**

I. Introduction

A color image consists of three primary colours, red, green, and blue. So when it is captured in a colour digital camera three arrays of colour sensors are required, each one for red, green and blue components. This increases the complexity of the electronics which processes the image. Now-a-days to decrease the complexity of the electronics inside the camera a single array of the three colour sensors is used [1]. The red, green, and blue sensors are interleaved in the array. Red and blue components make 25% and 25% of the pixels respectively and the green component makes 50% of the pixels. The image is a single array of the three colours and any processing to be done on the image is carried out on a personal computer. The interleaved pattern of the three primary colours in the image is called Bayer's pattern. This is also called colour filter array. There are other types of colour filter arrays. They have been discussed in [2] [3] [4]. The colour image is constructed from the CFA image in the personal computer and the method is called the demosaicing process. The demosaicing process itself is an avenue of research and there are different types of demosaicing algorithms available.

In older days the CFA images were converted into colour image and then compression algorithm were applied. This introduced a certain amount of redundancy into the compressed image. To overcome this in recent papers the compression algorithm is applied directly on the CFA images. There may be more correlation between the red and red pixels, blue and blue pixels and green and green pixels. So in some cases the compression is applied to the CFA image directly and in others the colour components are separated and compression is applied. When the colour components are separated then the CFA image is said to be deinterleaved CFA image. The Fig. 1 shows the deinterleaved CFA image.

Digital image Compression can be divided into two broad categories: they are lossless compression and lossy compression. Lossless compression is one in which the reconstructed image is the same as the original and there is no loss in the quality. Business documents and medical images are two places where lossless compression should be applied. In lossy to achieve a higher compression ratio the quality of the reconstructed image is compromised. This paper gives a novel algorithm which is a combination of the Haar wavelet and GPPM tree to compress the CFA image. GPPM tree does not introduce any error. But since Haar wavelet coefficients are rounded of it introduces some error in the reconstructed image.

The rest of the paper is organised as follows. Section II describes the GPPM based CFA image compression and Haar wavelet transform. Section III describes the proposed algorithm. Section IV describes the experimental results. Section V describes the conclusion.

Fig. 1.Deinterleaved CFA Image [2]

II. Procedure for Paper Submission

A. GPPM Tree in CFA Image Compression

GPPM tree is a data mining data structure which can be used for CFA image compression. Reference [2] uses GPPM tree and PPM tree in CFA image compression. The CFA image is split into bit planes and one of the following is selected as the data corresponding to the bit plane in the compressed file: (i) PPM tree (ii) GPPM tree and (iii) Raw data. Two bits are allocated for each of the eight bit planes to represent which of the above data is selected further the size of the image is selected for reconstruction. In the algorithm only square images are used. Let mxm be the size of the image and m = 2^p. P is stored for the size of the image.

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Reference [5] discusses about the Peano tree, Peano Pattern Mask tree, Generic Peano Pattern Mask Tree.

B. Haar Wavelet

Reference [6] describes how wavelet transform is taken for a 1D image with a resolution of four pixels. The 1D image is split into a new lower resolution image and detail coefficients. One low resolution coefficient and its corresponding detail coefficient are used to reconstruct two successive pixels when inverse Haar wavelet transform is taken. It also describes how Haar wavelet transform is taken for a 2D image. First 1D Haar wavelet transform is taken for each row and with the resulting coefficients again Haar wavelet transform is taken for each column. We consider this as separable scaling and wavelet filter. By this the LL, LH, HL, and HH components of the image are obtained.

III. ALGORITHM (CMCICHG)

The CFA image is read and one level 2D Haar wavelet transform is taken. The Haar wavelet coefficients have the LL, LH, HL, and HH components. In Haar wavelet transform for average of two successive pixels are taken for the low resolution image, so there is a possibility that the coefficients are real numbers. To facilitate the bit plane separation these values they are rounded of after the 2D Haar wavelet transform is taken. Also the Haar wavelet transformed coefficients have negative values in the detail coefficients since difference between two values are taken. To make the negative coefficients into positive numbers the following mapping is done. Let C (i,j) be the Haar wavelet coefficient, then f:C→I is as given below:

$$I(i,j)=\begin{cases} 2*C(i,j) & C(i,j)\geq 0 \\ -2*C(i,j)-1 & C(i,j)<0 \end{cases} \quad (1)$$

The largest value in the Haar wavelet coefficient is 255, since the biggest value for a CFA image pixel is 255, and average of 255 and 255 is 255, and when multiplied by 2 510 is obtained. So, when the Haar wavelet coefficient which is mapped to I is split into bit planes at the maximum nine bit planes are obtained.

Split the positively adjusted Haar wavelet transform coefficients into bit planes. For each bit plane (i) PPM tree (ii) GPPM tree and (iii) raw data are taken as explained in II.A. The one with the least size is taken to represent that bit plane in the compressed image. The compressed image is stored in a file and the file contains the following fields. (i) The size of the file as in II.A. (ii) Two bits for each bit plane to represent which of the three formats is used for storing the bit plane. (iii) The variable sized field which contains the data for the nine bit planes.

IV. EXPERIMENTAL RESULTS

As the Haar wavelet transform coefficients are rounded for facilitating the process of bit plane separation some of the details of the image are lost and the compression is near lossless method.

The images used for testing the performance of the compression by the CMCICHG algorithm are Bangladesh, bright1, bright2, bright3, circles1, circles 2, dellwallpaper1, dellwallpaper2, Jupiter and lena. CFA images are generated from the above images. The algorithm in [2] is used to compare the CMCICHG algorithm. The Fig. 2 shows the original image and the Fig. 3 shows the Haar wavelet of the original image. After the Haar wavelet is taken the mapping for negative coefficient adjustment is performed and split into bit planes. As the LH, HL, and HH coefficients are small more compression is achieved when compression is applied through the CMCICHG algorithm.

The compression is done with the algorithm in [2], the CMCICHG algorithm and the CMCICHG algorithm with deinterleaved CFA image. The compression ratio is used as the metric to compare the two algorithms. The compression ratio is defined as the ratio of the size of the original image and the size of the compressed image. The Table I shows the compression ratio for different images by using the algorithm in [2], CMCICHG algorithm and CMCICHG algorithm with deinterleaved CFA image. The chart in Fig. 4 shows the comparison of data in Table I. It is evident from the table I and fig. 4 that CMCICHG algorithm is clearly having greater compression ratio than the algorithm in [2]. The CMCICHG algorithm and CMCICHG algorithm with deinterleaved CFA image are having compression ratio which are very near to each other.

Fig. 2. Original Image [2]

V. CONCLUSION

The algorithm in [2], CMCICHG algorithm and CMCICHG algorithm with deinterleaved CFA image were compared for compression ratio and CMCICHG algorithm was found to be more efficient in compression ratio.

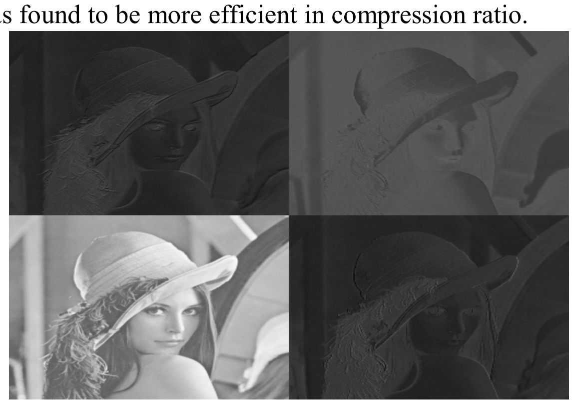

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Fig. 3 Haar wavelet Transform

This is evident from the figure. 4. This was due to the low values achieved by the Haar wavelet coefficients. This algorithm is an extension of [2] and the performance in terms of compression ratio is higher than algorithm in [2]. Also when the image has no variation in the image then the compression ratio is found to be more.

Table-I: Compression ratio of different images by algorithm in [2] and CMCICHG algorithm and CMCICHG algorithm with deinterleaved CFA image

Image	Algorithm in [2]	CMCICHG Algorithm	CMCICHG Algorithm with deinterleaved CFA image
Bangladesh	1.1337133	2.1669987	1.8759947
Bright1	1.3191228	5.6371417	4.7566548
Bright2	1.6919611	4.9253894	3.9321403
Bright3	1.1702387	1.4254626	1.3698639
Circles1	1.1847513	1.6319030	1.3939678
Circles2	1.0512630	1.4631511	1.3873136
Dellwallpaper1	1.4304095	7.0009614	6.4864651
Dellwallpaper2	1.3243342	6.7844406	5.1341389
Jupiter	1.2729701	1.3482554	1.4354852
Lena	1.0422879	1.4496449	1.3637813

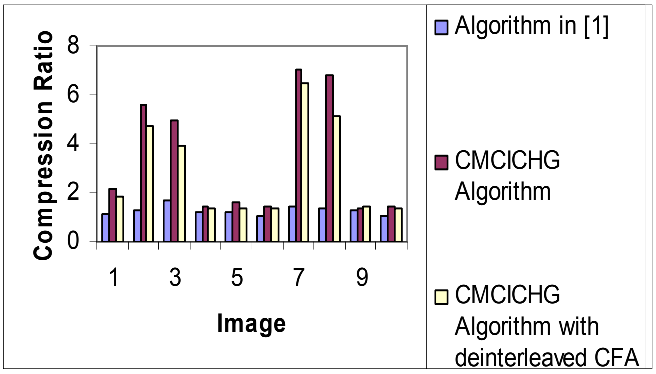

Fig. 4. Chart Comparing the Compression Ratio Achieved by algorithm in [2], CMCICHG Algorithm and CMCICHG Algorithm with deinterleaved CFA Image

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