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COMPRESSION OF SENSOR DATA IN DIGITAL CAMERAS BY PREDICTION OF PRIMARY COLORS

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Abstract— The Color Filter Array is a mosaic of tiny color filters placed over the pixel sensors of an image sensor to capture color information.CFA image is divided into 4 sub images. Each sub image contains G1, G2, R and B color components. G1 is encoded by using any conventional gray scale encoding technique. G2 is predicted from encoded G1 values which produces the prediction error $e\delta G2$. Then, the G pixels are interpolated to fill in the G values at the positions of the R and B pixels. Fourth, these interpolated G pixels are subtracted from the R and B pixels, producing δR. δR is predicted from encoded G1 value, predicted G2 value and already encoded R value produces the prediction error of red. δB is predicted from encoded G1 value and from both predicted G2 and B value and also from already encoded B value produces the prediction error of blue. The error signals obtained by the prediction block are fed into an entropy encoder. The choice of predictors and weights is of course based on the direction of edges around the x. We define the edge directivity around x and take smallest two of them and they are used for the calculation of weight and then by using the weight and predictors actual value is estimated. After estimating the value of G2, R and B, three errors are calculated. These three errors are fed into an entropy encoder like Huffman encoder and they are separately encoded. Then bits per pixel and compression ratio are calculated. It can be decoded by using a Huffman decoder. From images that are outputted by Huffman decoder, mosaic image is created by inverse prediction. After applying demosaicing and color reconstruction techniques, we get the original full color image.

Keywords—Color Filter Array, JPEG-LS, Huffman encoding and decoding, Gamma correction, White balance, Bilinear interpolation, Edge directivity

INTRODUCTION

In analogue cameras images are captured in a photographic film. The film and paper needs much processing inside a darkened room to get a clear image. Digital photography doesn't need dark room, film or chemicals. Image is captured with an array of photo sensors. This array is termed as color filter array. Conventional color filter array contains 3 sensors at each pixel position to capture primary colors ie, red, blue and green. Every other colors can be made by using these three colors. In order to reduce cost and size, today's digital cameras make use of one sensor at each pixel position. The rest two colors are determined by a process called demosaicing. Among all color filter arrays, Bayer color filter array is the most popular one. Figure 1 shows Bayer color filter array[1].

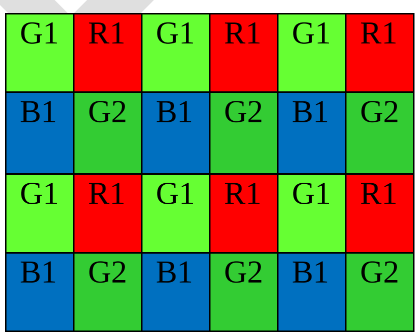

Figure 1 Bayer color filter array[1]

There are several demosaicing algorithms exist for attaining high image quality [2]. Efficient interpolation algorithms exists produce images that are similar to the original image. In conventional approaches, demosaicing is performed first. After the demosaicing process, compression is performed. This increases the number of bits for compression. So the compression ratio will be low. If compression is performed first, we can achieve better compression ratio since the number of pixels used for compression is less. So we prefer compression first scheme[3-7]. Figure 2.a shows Demosaicing first scheme and figure2.b shows compression first scheme. Image reconstruction includes color correction such as white balance, gamma correction and color correction.

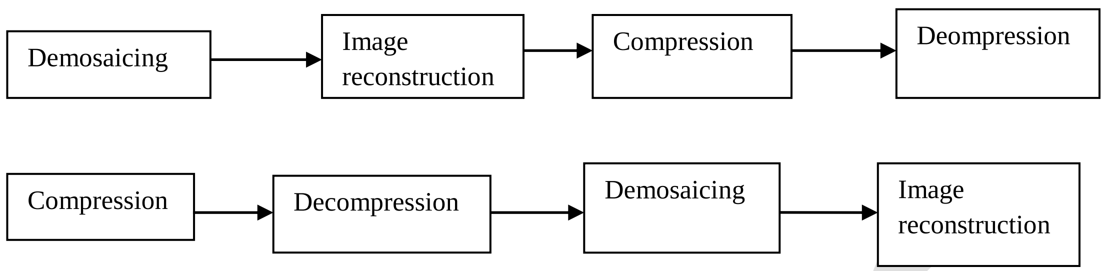

Figure 2 a) Demosaicing first scheme b) compression first scheme

In this paper a modified compression method using prediction is applied. Section 1 is proposed method, that includes compression of G1 sub image, compression of G2 sub image, compression of R and B sub images, section, error encoding, decoding and inverse prediction, bilinear interpolation and image reconstruction methods. Section 2 deals with

Proposed Method

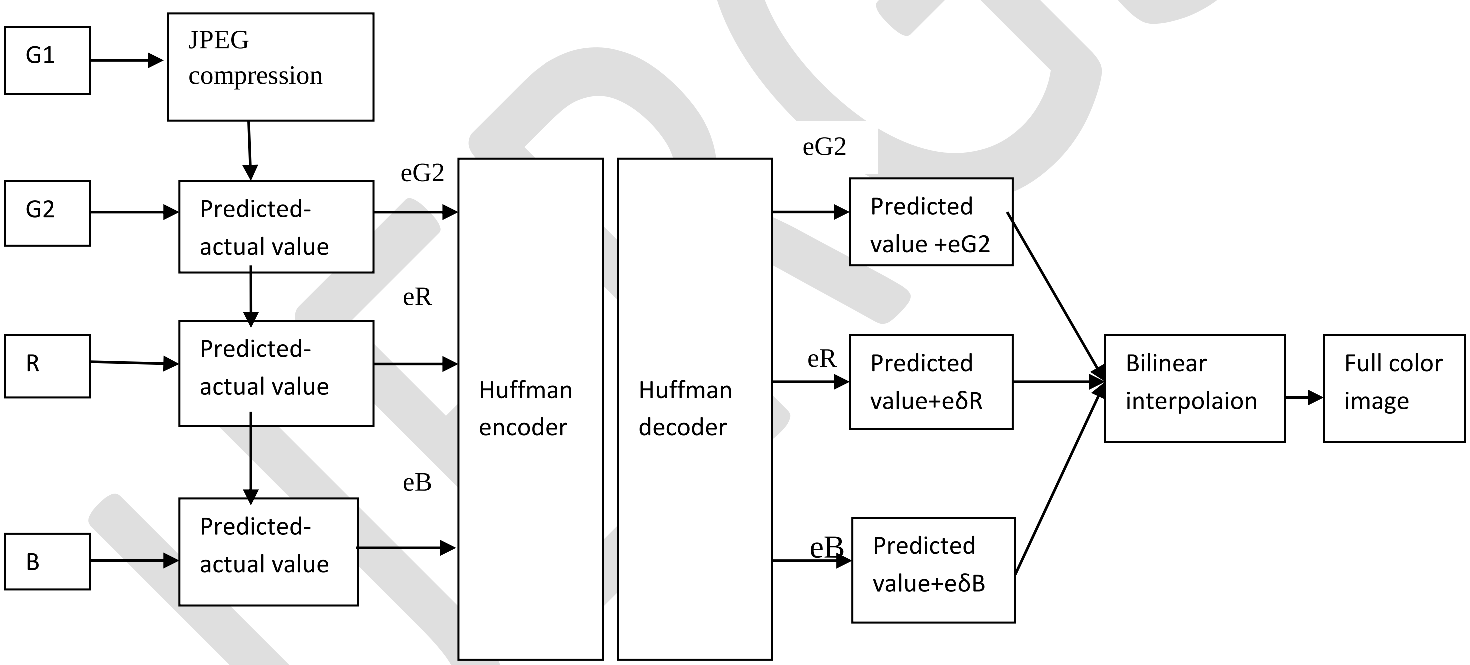

Figure 3 block diagram for lossless compression

The captured image from a camera is converted into a Bayer pattern mosaic image. From the bayer pattern, G1 sub image is separated and encoded using JPEG-LS[8] compression algorithm. Predicted G2 value is calculated from already encoded G1 sub image and pixels of already encoded G2 value. R value is calculated from already encoded G1 and G2 value and also from the already encoded pixels of red. B value is predicted from predicted values of G1, G2 and R and from already encoded pixels of B. Errors is calculated by subtracting predicted image from actual image. Errors are modeled and then compressed by Huffman encoding. Huffman decoding is performed and image is reconstructed using demosaicing technique.

1. Prediction of primary colors

G1 sub image is encoded by using jpeg compression method. This encoded value is used for predicting all other color components. Jpeg lossless compression is an efficient method for compression. The JPEG standard specifies the codec, which defines how an image is compressed into a stream of bytes and decompressed back into an image, but not the file format used to contain that stream. G2 sub image is predicted from encoded G1 sub image and also from already encoded pixels of G2 sub image. We define four predictors in four directions. Among them we take best two predictors. The predictors are:

G11	R12	G13	R14	G15	R16
B21	G22	B23	B24	B25	G26
G31	R32	G33	R34	G35	R36
B41	G42	B43	X	B44	G45
G51	R52	G53	R54	G55	R56

Fig 4 G2 predicton

$$ph = B24,\ \ pv = G42\ , pr = G35 + G53/2, pdl = G33 + G55/2$$

Edge directivity in these 4 directions can be calculated by the following equation.

$$Dir = \frac{pixel\ difference\ in\ the\ direction\ of\ X}{difference\ between\ pixel\ pairs}$$

From the all four edge directivity values, smallest and second smallest values are taken, which denote Dir1 and Dir2 respectively. Weight can be calculated by using the equation $w1 = Dir1 + 1$ and $w2 = Dir2 + 1$

The G2 sub image can be calculated by using the equation $G2 = \frac{P1 \times w1 + P2 \times w2}{w1 + w2}$ where p1 and p2 will be the predictors in the directon of D1 and D2.

The value of Green at positions of red and blue have to be calculated. For that the same procedure used for G2 prediction is used. In order to find the real R and B values, we have to subtract the interpolated green value from the R and B values to yield δR and δB. For further prediction of red and blue colors we use δR and δB instead of R and B values. δR and δB predictions are carried out by following the same procedure that is used for G2 prediction. Firstly, four directional predictors are defined for δR and δB. After that four edge directivity values are calculated. Then final predicted value is calculated by using best two predictors and their weights for both δR and δB.

2. Error Encoding

The prediction errors for primary colors are determined by subtracting the prediction value from the actual value of image which yields three error images. These images are fed as input for Huffman encoder[10]. Huffman encoding is a lossless image compression technique. Huffman coding is well suited for gray scale image compression. Since the error images obtained are gray scale, the compression ratio is high.

3. Error decoding and inverse prediction

Error decoding is carried out by Huffman decoding algorithm. Encoded error image is fed as input for Huffman decoder. It recreates three error images. Inverse prediction is applied to the three error images and has to recreate green, red and blue sub-image. Combining these three images will create a mosaic image. Demosaicing is applied o this mosaic image to get the full color image.

4. Bilinear interpolation

Bilinear interpolation takes the closest 2×2 grid surrounding the unknown pixel. The four surrounding pixels are averaged to get the interpolated value of unknown pixel. This interpolation method yields smoother image compared to nearest neighbor interpolation method. Figure 4 shows bilinear interpolation.

5. Image reconstruction

Image reconstruction phase includes white balance, gamma correction and color correction to get a better quality full color image. Without gamma correction, the pictures captured by digital cameras will not look like original image. White balance is based on color temperature. Digital cameras have great difficulty in auto white balance. Since this is a lossless compression method, the image obtained is an exact replica of the original image.

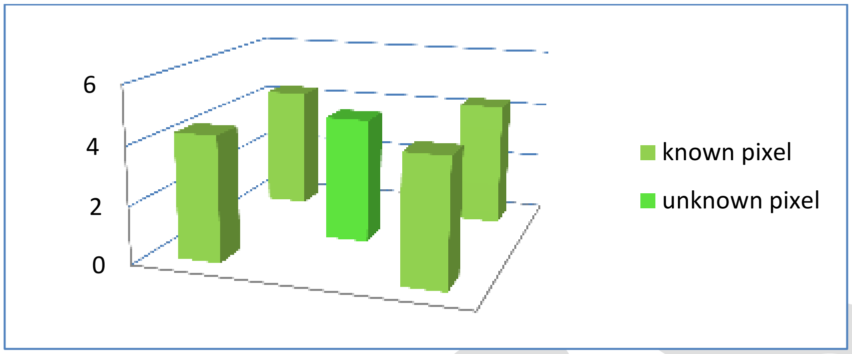

Figure 4 bilinear interpolation

PERFORMANCE EVALUATION

In the proposed method, the lossless compression algorithm is applied to figure 5a. The demosaiced image is shown in figure 5b and the final reconstructed image is shown in figure 5c. The bits per pixel value obtained for this method is 2.6550and the compression ratio is high compared to other existing methods.

Figure 5a. Original image 5b. Decoded demosaiced image 5c. Output image

CONCLUSION

Here proposed a prediction based lossless compression method that uses primary colors such as green, blue and red. Bayer pattern is the most popular color filter array. G1 sub-image is predicted by using lossless JPEG compression algorithm. The order for predicting colors are green, red and blue respectively. Error is calculated by subtracting the predicted image from actual image. These three error images are generated for green, red and blue. These three error images are fed as input for Huffman encoder. After transmission and storage, it can be decoded using Huffman decoding algorithm. From the decoded images, we can reconstruct the mosaic image. After performing, demosaicing and image reconstruction technique, we get the full color image. This methods yields good image quality and also less bits per pixel compared to other existing methods.

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