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Color Filter Array Demosaicing in Bayer Pattern By The Prediction of Missing RGB

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Abstract— Instead of beam splitters in digital cameras in this paper proposes an inexpensive technique using color filter arrays because it uses single sensor to capture multi color information. Single sensor digital cameras captures only one color at each pixel location and the other two color information to be interpolated is called Color Filter Array (CFA) interpolation or demosaicing**.** In this paper the missing green samples are first estimated, then missing red and blue samples are then estimated based on the estimated green plane. Gradient are used for extracting directional data from the input images. The Green channel interpolation is based on the directionally weighted gradient method and the directional color difference is used along with the directional data. Using the interpolated Green channel the red and blue channel get interpolated. With the completion of red and blue pixel the full color image is to be generated.

Keywords— Beam splitters, cfa interpolation, demosaicing, gradient, weighted gradient, directional data, color reconstruction.

INTRODUCTION

Demosaicing algorithm is a digital image process used to reconstruct a full color image from the incomplete color samples obtained from an image sensor overlaid with a color filter array (CFA). Also known as CFA interpolation or color reconstruction [1] .The reconstructed image is typically accurate in uniform-colored areas, but has a loss of resolution and has edge artifacts in non uniform-colored areas.

A color filter array is a mosaic of color filters in front of the image sensor. The most commonly used CFA configuration is the Bayer filter shown in Fig 1.1. This has alternating red (R) and green (G) filters for odd rows and alternating green (G) and blue (B) filters for even rows. There are twice as many green filters as red or blue ones, exploiting the human eye's higher sensitivity to green light.

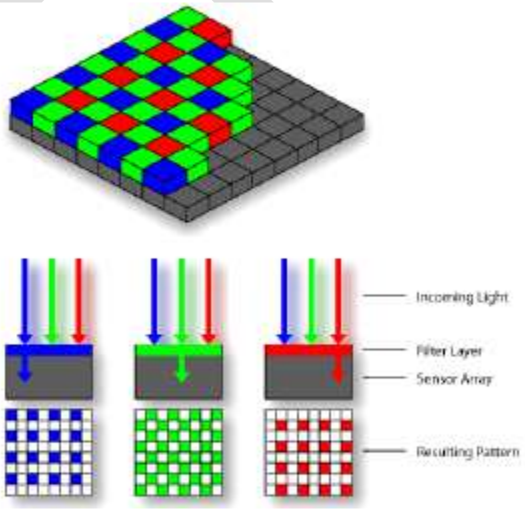

Figure 1.1 Bayer mosaic of color image

This paper is organized as follows: In section 2 includes the related works. The proposed method is explained in section 3. Ultimately section 4 concludes the proposed work.

RELATED WORKS

Nearest neighbor interpolation simply copies an adjacent pixel of the same color channel (2x2 neighborhood). It is unsuitable for any application where quality matters, but can be used for generating previews with given limited computational resources [17]

In bilinear interpolation**,** the red value of a non-red pixel is computed as the average of the two or four adjacent red pixels. The blue and green values are also computed in a similar way. Bilinear interpolation generates significant artifacts, especially across edges and other high-frequency content, as it doesn`t take into account the correlation between the RGB values [14].

Cubic interpolation takes into account more neighbors than in algorithm no. [14] (e.g., 7x7 neighborhood). Lower weight is given to pixels which are far from the current pixel.Gradient-corrected bilinear interpolation assumes that in a luminance/chrominance decomposition, the chrominance components don`t vary much across pixels. It exploits the inter-channel correlations between the different color channels and uses the gradients among one color channel, to correct the bilinearly interpolated value [15].

Smooth hue transition interpolation assumes that hue is smoothly changing across an object's surface; simple equations for the missing colours can be obtained by using the ratios between the known colours and the interpolated green values at each pixel [14]. Problem can occur when the green value is 0, so some simple normalization methods are proposed [16].

Another interesting approach is to interpolate the green channel in both directions and then to make a posteriori decision based on sum of gradients in each direction[5].The demosaicing problem has been studied from many other angles. Glotzbach et al.proposed a frequency domain approach where they extracted high frequency components from the green channel and used them to improve red and blue channel interpolation[6]. he full range of demosaicing Gunturk et al. used the strong spectral correlation between high frequency sub bands to develop an alternating projections method [7].

Algorithms [2][3] hypothesize that the quotient of two color channels is slowly varying, following the fact that two colors occupying the same coordinate in the chromaticity plane have equal ratios between the color components. Alternatively, [4][6][10][9] assert that the differences between red, green, and blue images are slowly varying. This principle is motivated by the observation that the color channels are highly correlated. The difference image between green and red (blue) channels contains low-frequency components only. A more sophisticated color channel correlation model is explored in [7]. Moreover, [3][10][8] incorporate edge-directionality.Interpolation along an object boundary is preferable to interpolation across this boundary for most images.

PROPOSED METHOD

For extracting directional data from digital images gradients are used. Several demosaicing methods including a recent integrated gradients method proposed in [11] made use of them. In [12] demonstrated that the gradients of color difference signals could be valuable features to adaptively combine directional color difference estimates Here we use weighted gradient method using sobel mask. The modules of the proposed system framework are illustrated in Fig 2.1. The first step of the algorithm is to find the gradients along the four direction of the mosaic image, that means horizontal, vertical, right diagonal and left diagonal.

$$G^{H}_{i,j} = \left|(\mathrm{m}(\mathrm{i}+1, \mathrm{j}-1) + 2*\mathrm{m}(\mathrm{i}+1, \mathrm{j}) + \mathrm{m}(\mathrm{i}+1, \mathrm{j}+1)) - \mathrm{m}(\mathrm{i}-1, \mathrm{j}-1) + 2*\mathrm{m}(\mathrm{i}-1, \mathrm{j}) + \mathrm{m}(\mathrm{i}-1, \mathrm{j}+1)\right| \quad (1)$$

$$G^{V}_{i,j} = \left|(\mathrm{m}(\mathrm{i}-1, \mathrm{j}+1) + 2*\mathrm{m}(\mathrm{i}, \mathrm{j}+1) + \mathrm{m}(\mathrm{i}+1, \mathrm{j}+1)) - \mathrm{m}(\mathrm{i}-1, \mathrm{j}-1) + 2*\mathrm{m}(\mathrm{i}, \mathrm{j}-1) + \mathrm{m}(\mathrm{i}+1, \mathrm{j}-1)\right| \quad (2)$$

$$G^{rd}_{i,j} = \left|(\mathrm{m}(\mathrm{i}-1, \mathrm{j}) + 2*\mathrm{m}(\mathrm{i}-1, \mathrm{j}+1) + \mathrm{m}(\mathrm{i}, \mathrm{j}+1)) - \mathrm{m}(\mathrm{i}, \mathrm{j}-1) + 2*\mathrm{m}(\mathrm{i}+1, \mathrm{j}-1) + \mathrm{m}(\mathrm{i}+1, \mathrm{j})\right| \quad (3)$$

$$G^{ld}_{i,j} = \left|(\mathrm{m}(\mathrm{i}-1, \mathrm{j}) + 2*\mathrm{m}(\mathrm{i}-1, \mathrm{j}-1) + \mathrm{m}(\mathrm{i}, \mathrm{j}-1)) - \mathrm{m}(\mathrm{i}+1, \mathrm{j}) + 2*\mathrm{m}(\mathrm{i}+1, \mathrm{j}+1) + \mathrm{m}(\mathrm{i}, \mathrm{j}+1)\right| \quad (4)$$

where *H, V, rd and ld* denote horizontal, vertical, right diagonal and left diagonal directions and *(i, j)* is the pixel location. For every pixel coordinate, we now have a true color channel value

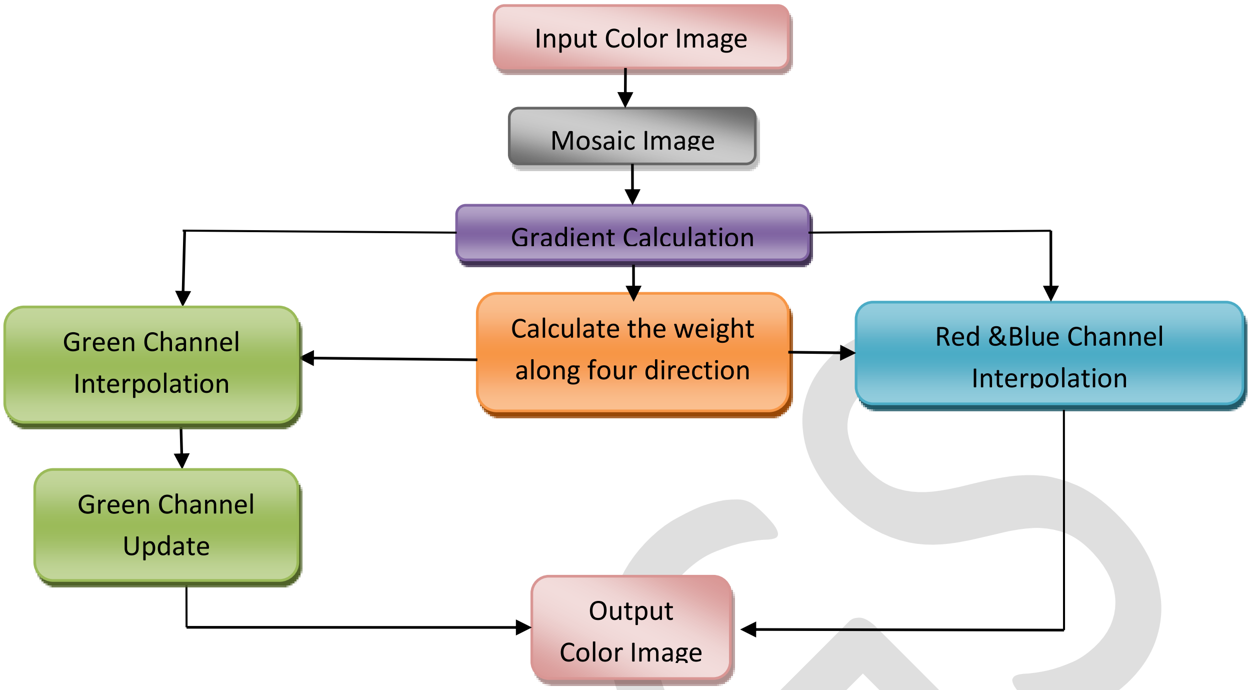

Fig.2 Block diagram of proposed system

Next Step is to find the weight along the same four direction The weights for horizontal, vertical directions, right diagonal, and left diagonal(W_H, W_V, W_{rd} , W_{ld}) are calculated by adding color gradients over a local window. For a local window size of 5 by 5,the weight for each direction is calculated as follows

$$W_H(i,j) = \left|1/(1+G_{i,j}^{H})\right| \tag{5}$$

$$W_V(i,j) = \left|1/(1+G_{i,j}^{V})\right| \tag{6}$$

$$W_{rd}(i,j) = \left|1/(1+G_{i,j}^{rd})\right| \tag{7}$$

$$W_{ld}(i,j) = \left|1/(1+G_{i,j}^{ld})\right| \tag{8}$$

Green Plane Interpolation

The next step of the algorithm is to reconstruct the green image along horizontal and vertical directions. Initial green channel interpolation section concentrates on estimating missing green pixels from known green and red pixel values using the green-red row of Bayer pattern. The same technique is used in estimating missing green pixels from known green and blue pixels[13].Following equation is done in both red and blue planes

$$G(i,j) = \sum_{i=3}^{x-2}\sum_{j=4}^{y-2} (W_H(i,j) * (m(i,j-1) + m(i,j+1))/2 + W_V(i,j) * (m(i-1,j) + m(i+1,j))/2)/W_H(i,j) + W_V(i,j) \tag{9}$$

$$G(i,j) = \sum_{i=4}^{x-2}\sum_{j=3}^{y-2} (W_H(i,j) * (m(i,j-1) + m(i,j+1))/2 + W_V(i,j) * (m(i-1,j) + m(i+1,j))/2)/W_H(i,j) + W_V(i,j) \tag{10}$$

Green Channel Update

After green channel interpolation next is its updation this will improve the green channel results. We consider the closest four neighbours of the target pixel with each one having its own weight.

Red & Blue Channel Interpolation

After the green channel has been reconstructed, interpolate the red and blue components. The most common approach for red and blue estimation consists of interpolation of the color differences R-G, B-G instead of R and G directly. Finally, the missing blue (red) components at the red (blue) sampling positions are interpolated[13].For the green position following equations are used

$$R(i, j) = \sum_{i=3}^{x-2}\sum_{j=3}^{y-2} (W_H(i, j)*(m(i, j-1)+m(i, j+1))/2)/W_H(i, j) \tag{11}$$

$$R(i, j) = \sum_{i=4}^{x-2}\sum_{j=4}^{y-2} (W_V(i, j)*(m(i-1, j)+m(i+1, j))/2)/W_V(i, j) \tag{12}$$

Next for the blue position equation will be

$$R(i, j) = \sum_{i=4}^{x-2}\sum_{j=3}^{y-2} (W_{rd}(i, j)*(m(i-1, j+1)+m(i+1, j-1))/2+W_{ld}(i, j)*(m(i-1, j-1)+m(i+1, j+1))/2)/W_{rd}(i, j)+W_{ld}(i, j) \tag{13}$$

Similarly, we interpolated the blue channel. With the completion of red and blue pixel values we obtain a full color image.

CONCLUSION

This method produces better results in terms of image quality. It does not require any thresholds as it does not make any hard decisions. It is non iterative[13]. In this paper we proposed a weighted gradient method using sobel mask because of this the gradient calculation is more accurate, weight ratio will be more close to the pixel color ratio of the mosaic image and the interpolation will be more perfect.

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