Directional LMMSE Demosaicking over ordinary Demosaicking for Single Sensor Camera Image

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Abstract : In most of the digital cameras, single sensor cameras are used for image acquisition with a color filter array (CFA). But these images are saved in unrefined format still. These are going to further process to become color images. This becomes a reason for noise generation in images. Noise is very to remove. Numbers of technique are used to denoise the captured images but because of various limitations, techniques are not up to the mark. In this work, we introduce a technique which gives the satisfactory result. In this technique, 2D image is converted into High pass and Low pass component then denoised the high pass component and further merge with the low pass component again. Now it is required a demosaicking process. A directional LMMSE demosaicking process is used. To estimate the system performance different parameters is used such as SNR and visual quality.

***IndexTerms* - PSNR, LMMSE, CFA**

I. INTRODUCTION

An image denoising process must be the one which can remove the noise component from the image while keeping the information unaltered. Various traditional methods have been used which include the linear and nonlinear methods. Linear methods have the advantage in terms of speed while a major disadvantage is that they cannot preserve the image content in the way they should [1]. Nonlinear methods can handle information preservation but have speed limitations. At present the techniques are not developed to such level, they are compelled to use simple Bayer pattern color filter array. Many famous technical personalities are B.K.Gunturk, Y. Altunbasak and R. M. Mersereau et al [7]. At the place of the every pixel, only coloring specimen is taken and the estimations of the other hues must be interjected utilizing neighboring test. The interjection of the above mentioned shading plane in termed, demosaicking. Demosaicking has been regarded as the most critical undertaking in the modern world of computerized camera pipeline. The most common way to find on survey between digital cameras is that they use single sensor array. On different examination of experiment has been found that RGB are three essential hues of every pixel. Color demosaicking is the procedure for reproducing a full color picture, the missing shading examples need to be interjected. The factor on which the nature of the reproduced color picture relies is the picture substance and demosaicking strategy.

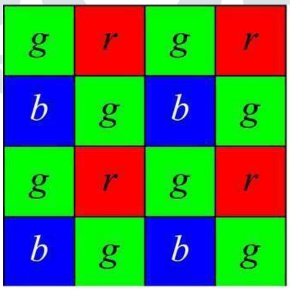

Figure 1: Bayer Pattern

Before the present technique we were using the nearest neighbor technique, Bilinear interpose and couple of the other different methods to demosaick the image. Major problem, the earlier methods used to suffer were blurring, blocking and zipper effect at the edges. (SHT) the smooth hue transition methods interpose the luminance channel i.e. green and chrominance channels i.e. red and blue. After the obtaining of green color by Bilinear interpolation, we get red and blue channel by Bi- linearly interposing the red hue (ratio of red to green) and blue hue (ratio of blur to green). Due to some interaction between red, blue and green channels, these resulted in a large interpolation error in red and blue channels when green values unexpectedly modified.

Many demosaicking methods avoid interpolation at the edges, as human visual systems are very perceptive to the edge organization in the image. Directional filtering is very prominent way for color demosaicking that gives complete information. Second order [2] Laplacian filter is the one of the most popular and best known directional interpolation scheme. One of the demosaicking methods is interactive method, which can be used with gradient-based method. This process consists of two steps, i.e. an enhancement step and reconstruction step[13]. We calculate eight directional derivatives at each pixel based on the eight neighbors. Another interactive demosaicking strategy was given by Gunturk[7]. This proposed that investigating the way that the three color channel of a characteristics picture are profoundly connected. The first step involving is the picture insertion by Bilinear or demosaicking routine. Second step involving is that the green channel is upgraded by high recurrence data of red and blue channels. Finally wavelets based interactive procedure was utilized to upgrade the high recurrence point of intersect of red and blue channel as indicated by the green channel. In all sort of color demosaicking strategy inclination examination plays an essential part in producing sharp edges. On other hand inclination estimation may not be hearty when the info sign surpasses the Nyquist recurrence. This demonstrates that the fundamental driver of shading relies in demosaicked picture. As an observation, we found that the three colors and three shading channels are inter-related and works hand in hand.

II. MINIMUM MEAN SQUARE ERROR

Minimum mean square error is a determination method which works on the principal of calculating the color difference signals[11]. This method provides an approximation to the optimal determination in the mean square error. This process is a bi-directional method and outputs in vertical and horizontal direction and then fuses optimally to remove the demosaicking. At the end, full resolution of three color channels are rebuilt from the minimum mean square error determination filtered difference signals. From experimental results and observation it is proved that this new color demosaicking technique gives better improvement in PSNR measure and visual perception. Bayer pattern also uses this technique, but it can be elongated for CFA pattern also. We calculate red-green and blue-green difference images for favoring the spectral inter-relations [5]. This color difference are called primary difference signal (PDS).

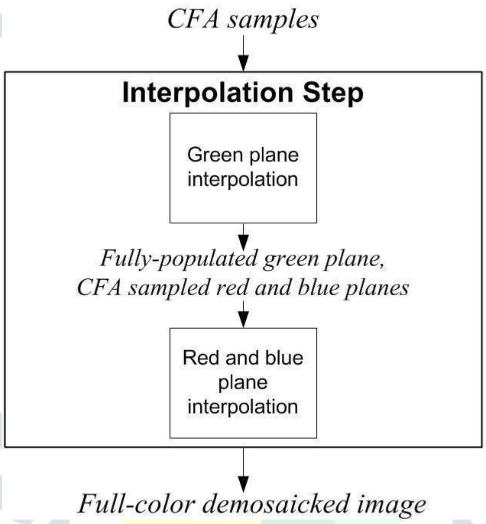

Figure 2: Algorithm for demosaicking

A linear model is used to show and calculate the red-green and blue-green PDS signals. Observed PDS values are showed as the sum of color interpolation error (IE) and true PDS (MMSE) method is used for the calculation of PDS. We determined a full resolution green image. The red and the blue channels are then often recovered.

III. PRIMARY DIFFERENCE SIGNALS AND DIRECTIONAL DEMOSAICKING NOISE :-

Nyquist frequency of color filter array is used for estimation of high frequency countenance. Nyquist frequency is a demosaicking scheme which depends on some additional properties for input color signals. 'The red' and 'the blue', the 'The green' is most common property in inter-relation between the sampled primary color channels. There are numbers of reasons that why the green channels has a major role in our determination of omitted color samples. For the foremost, green channel has the doubles of the total samples, as the other two channels in the Bayer mosaic pattern. At some next, perceptiveness of the human eye at the green wavelength. At some more next, the green channel is close to the red and the blue then the difference signal between the red and the blue in wavelength. Some of the PDS signals are denoted by

$$g, r(n) = G_n - R_n$$
$$, b(n) = G_n - B_n$$

Where 'n' indicate the position index of the pixel. Random process has some statistical properties that can be extracted for demosaicking, so, PDS calculates. Second order directional laplacian filter which depends on a robust basis which outputs will be g, r and g, b as constant in both directions.

$$Ihg, r(i) = IG\ hi - R'hi$$

G is interpolated.

We have seen the Bayer samples. A section and a column of exchanging green and red specimens cross at a red inspecting location, where the missing green quality is to be resolved.

We denote the red samples at the center of the window as 'Ro'. It interlaced red and green neighbors in horizontal directions are labeled as, RH i,i^2…..-4,-2,2,4 and GH I, i^2…..-3,-1,1,3 respectively. At the same extent, neighbors of red at center (ro) are Rho and Rvi in both directions. To get some of the dimensions of the PDS [g,r and g,b]. We require interpolating the emitted green samples at red and blue pixels and then interpolating the missing samples of red and blue at green.
For any red original sample rHi or rHj, the corresponding green samples are,

$$IG_{hi} = ½ (G_{hi-1} + G_{hi-2}) + ¼ (2.R_{hi} – R_{hi-2} – R_{hi+2})\ IG_{vj}$$
$$= ½ (G_{vj-1} + G_{vj+1}) + ¼ (2.\ R_{vj} – R_{vj-2} – R_{vj+2})$$

Similarly for original green sample G_{hi} or G_{vj} the corresponding missing red sample is interpolated as

$$IR_{hi} = ½ (R_{hi-2}+R_{hi+1}) + ¼ (2.\ G_{hi} – G_{hi-2} – G_{hi+2})$$
$$IR_{vi} = ½ (R_{vi-2}+R_{vi+1}) + ¼ (2.\ G_{vi} – G_{vi-2} – G_{vi+2})$$

From the above procedure the input data which is intersected at red sample position is,

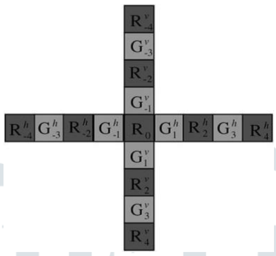

Figure 3: Row and column of mosaic data that intersect at red sample position

G hi – IR hi, R is interpolated and

I vg, r (i) = IG vi – R vi , G is interpolated

= G vi – IR vi, R is interpolated

The measurement error which has been discovered during the experiment associated with $I_{hg,\ r}$ and I.

$$E_{hg,r} = {}_{g,r} – E_{hg,r}$$
$$E_{vg,r} = {}_{g,r} – E_{vg,r}$$

After the evaluation of all the algorithm and abridge of notation and experiment we found, optimal minimum mean square error estimation,(MMSE) of x is $E_{vg,r}$.

IV. INTERPOLATION OF OMITTED RED [BLUE] SAMPLES AT THE BLUE [RED] SAMPLE LOCATION:

Before beginning up with any first and foremost we need to interpolate the omitted red sample at a blue pixel Bn. [R_{nnw}, R_{nsw}, R_{nne}, R_{nse}] are the four most closest neighbors for the samples position (blue) Bn. From the use of original sample and the preference of Bayer pattern, the estimated green samples at these location are expressed by

$$G_{1nwn}, G_{1swn}, G_{1nen}, G_{1sen}, G_{1n}$$

At the tip, omitted red specimen is assessed as

$$R_{1n}= G_{1n} – n,\ gr$$

As the previous, we can inject the blue missing samples at red sample position (Rn).
Accessibilities of Rn position are

$$X1 = M[x/y] = \int xp\ (x/y)dx$$

From the above, the MMSE is extremely extreme, conceivable means P(x/y) is called practically speaking. The LMMSE of x is computed and outputs as

$$X = M[x] + cov(x,y)/var(y)*(y – M[y])$$

From the experimental examination the demosaicking noises $E_{hg,r}$ and $E_{vg,r}$ are zero mean random process. From all the equation formed above we need to rectify and conclude as

$$X1 = \mu_x + \{ S_x\ ^\wedge 2/\ S_x{}^\wedge 2 + S_y{}^\wedge 2\}*\ (y - \mu_x)\text{Where}$$
$$\mu_x = m\ [x],\ S_x\ ^\wedge 2 = Var(x),\ S_y{}^\wedge 2 = vay(y)$$

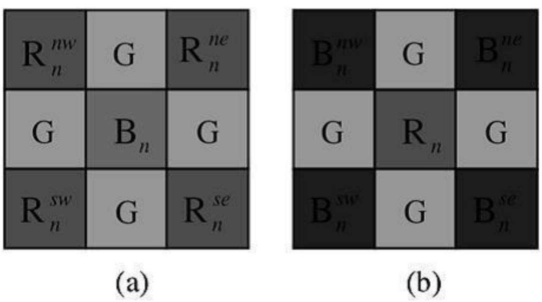

Figure 4: (a) Blue sample and its four nearest red neighbors. (b) Red sample and its four nearest blue neighbors

V. INTERPOLATION OF OMITTED RED/BLUE SAMPLES AT THE GREEN SAMPLES LOCATION:

At the beginning of process when the omitted samples of (red/blue) or (blue/red) are filled. We come across four cases. As the previous (1), is marked as the original sample when experimentally calculated. Given [when discussing first]

$$G_{1nn}, G_{1sn}, G_{1en} \text{ and } G_{1wn} \text{ at the position } R_{1nn}, R_{1sn}, R_{1en} \text{ and } R_{1wn}$$

Then, the omitted red samples at green sample position Gn is estimated to be

$$R_{1n} = R_{1n} – n,gr$$

As such, likely the omitted blue samples at a given position Gn is estimated as

$$B_{1n} = G_{1n} – n,gb$$

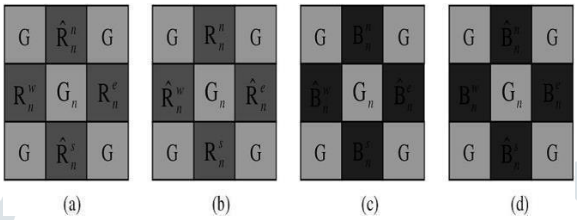

Figure 5: (a)(b) Green sample and its two original and two estimated red neighbors. (c)(d) Green sample and its two original and two estimated blue neighbors

The full color picture is remade. The exhibited demosaicking plan for mostly adventures the relationship between the green and red/blue channel to acquire great appraisals of the omitted green specimen and then gauges the missing red and blue average of green and red differences.

VI. ALGORITHM AND RESULTS:

1) INPUT INTAKE: Take image for denoising.
2) DATA TRANSFORMATION: Take CFA data for denoising.
3) PARAMETER ESTIMATION: Estimation of noise standard deviation
4) DECOMPOSITION: Decompose the image in its high-pass and low-pass components.
5) PCA DENOISING: Set the value for variable block size and training block size and then determine co-variance matrix.
6) DENOISING: Denoise the high-pass component
7) DEMOSAICKING: Through ordinary and linear MMSE estimation process.
8) COMPARISSION: Compare both the process.

SNR (i) indicates signal-to-noise ratio of input original image.
SNR (d) indicates signal-to-noise ratio of input denoised image.
SNR-R indicates signal-to-noise ratio of red component of image after demosaicking.
SNR-G indicates signal-to-noise ratio of green component of image after demosaicking.
SNR-B indicates signal-to-noise ratio of blue component of image after demosaicking

Table 1: SNR Analysis for Figure 4.

SNR analysis	Ordinary	LMMSE
SNR(i)	25.1616	26.5454
SNR(d)	30.5416	31.6348
SNR-R	29.6126	30.9007
SNR-G	30.6169	31.6213
SNR-B	31.2231	31.5997

Table 1: SNR Analysis for Figure 4.

SNR analysis	Ordinary	LMMSE
SNR(i)	24.6565	26.5454
SNR(d)	29.5368	31.6348
SNR-R	28.7659	30.9007
SNR-G	29.9535	31.6213
SNR-B	30.6552	31.5997

VISUAL RESULT:

Fig. 6: Original Image

Fig. 7: Grayscale Image

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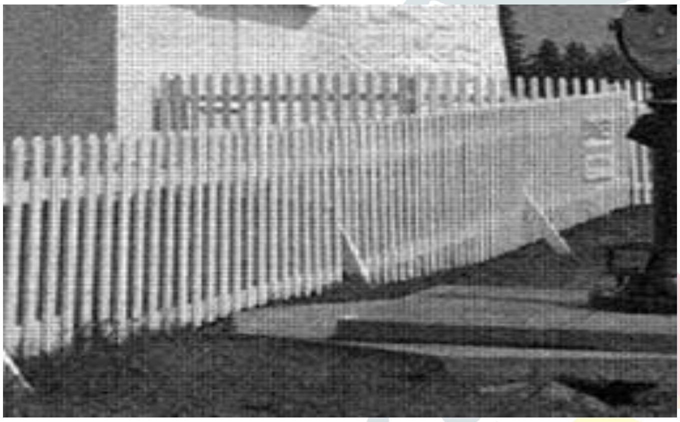

Fig. 8: Noisy Image

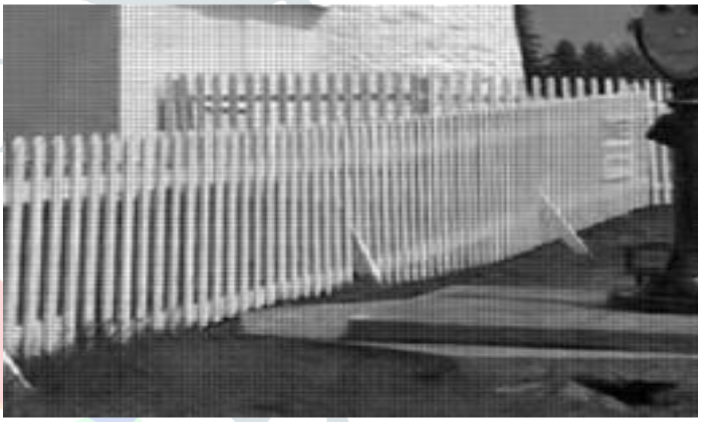

Fig. 9: Denoised Image.

Fig. 10: Ordinary Demosaicked Image

Fig. 11: LMMSE Demosaicked Image

Fig. 12: Gray Scale Image

Fig. 12: Noisy Image

Fig. 13: Denoised Image

Fig. 14: Ordinary Demosaicked Image

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Fig. 14: LMMSE Demosaicked Image.

We can concluded from the result evaluation on the basis of PSNR and visual quality as shown above the demosaicking process using linear minimum mean square method over ordinary technique have better results. As shown above the PSNR value for the ordinary technique is 30.5416 dB for the image fence and 29.5368 dB for the image baby where as linear minimum mean square method the PSNR value is 31.6348 dB for the image fence and 31.6348 dB for the image baby. Also the visual quality is better for the linear minimum mean square method as compare to the ordinary technique.

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