A Novel Method for Enhancing Satellite & Land Survey Images Using Color Filter Array Interpolation Technique (CFA)

Suma Chappidi[1], Sandeep Kumar Mekapothula[2]

[1]PG Scholar, Department of ECE, RISE Krishna Sai Gandhi Group of Institutions, Ongole

[2] Assistant Professor, Department of ECE, RISE Krishna Sai Gandhi Group of Institutions, Ongole

Abstract

Satellite images are being used in many fields of research. One of the major issues of these types of images is their resolution. In this paper, we proposed a new method for satellite image resolution enhancement technique based on the CFA interpolation. The proposed technique has been tested on satellite benchmark images. A commercial digital camera captures only one of the channels at each pixel location and the other two needs to be estimated to generate the complete color information this process is called color filter array (CFA) interpolation. In order to reduce the cost, the use of one sensor per channel has been avoided with the use of color filter array (CFA) .The red and blue images are sampled at a lower rate, so if standard interpolation techniques are used, the reconstructed red and blue images will be missing some high frequency information and could contain distortions from aliasing. This paper proposes a method of CFA interpolation that combines information from the green image with the subsample red and blue images to attack these problems. The green high-frequency information is added to the interpolated red and blue images to increase the sharpness of the output and is also used to estimate the aliasing in the interpolated red and blue images, providing a means of reducing the appearance of the aliasing distortions.

Keywords- Satellite image resolution enhancement, CFA interpolation, communication and texture

1. INTRODUCTION

Satellite technology in the areas of remote sensing, communication and navigation can provide valuable information in a number of areas from business to disaster -management to agriculture. There is great potential for such technology to help solve problems in developing countries. Satellite images are being used in many fields of research. One of the Major issues of these types of images is their resolution and poor contrast of the images. In this paper, we propose a new satellite image resolution enhancement technique based on the interpolation of the high-frequency obtained by CFA and the input image. Resolution of an image has been always an important issue in many image- and video processing Applications, such as video resolution enhancement, feature extraction, and satellite image resolution enhancement. Interpolation in image processing is a method to increase the number of pixels in a digital image. Interpolation has been widely used in many image processing applications, such as facial reconstruction and image resolution enhancement. This paper proposes a method of CFA interpolation that combines information from the green image with the subsample red and blue images to attack these problems. The green high-frequency information is added to the interpolated red and blue images to increase the sharpness of the output and is also used to estimate the aliasing in the interpolated red and blue images, providing a means of reducing the appearance of the aliasing distortions. The growing popularity of digital photography demands every attempt of improvement in terms of quality and speed of the features provided in digital cameras. The heart of a digital still or video camera is its sensor, a 2-D array of Photo sites that measure the amount of light absorbed during the exposure time. The color information is obtained by means of a color filter array (CFA) overlaid on the sensor, such that each photo site is covered by a color filter sensitive to only a portion of the visible light spectrum [7].Color images require multiple data samples for each pixel as opposed to grayscale images for which a pixel is represented by only one data sample. For the RGB image format, these data samples represent red, green and blue channels. A typical digital camera captures only one of these channels at each pixel location and the other two needs to be estimated to generate the complete color information. This process is called color filter array (CFA) interpolation or demosaicing. Although many different CFA patterns have been proposed, the most prevalent one is the Bayer pattern shown in Fig1. As an important step in image processing pipeline of digital cameras, demos icing has been an area of interest in both academia and industry. The simplest approach to the demos icing problem is to treat color channels separately and fill in missing pixels in each channel using a spatially invariant interpolation method such as bilinear or bi-cubic interpolation. While such an approach works fine in homogenous areas, it leads to color artifacts and lower resolution in regions with texture and edge structures. Obtaining better demosaicing performance is possible by exploiting the correlation between the color channels. Spectral correlation can be modeled by either constant color ratio rule [2], [3] or constant color difference rule [4], [5]. The basic assumption is that color ratio/difference is constant over a local distance inside a given object. This assumption is likely to break apart across boundaries; hence many demosaicing algorithms try to utilize it adaptively in one way or another. Since the Bayer CFA pattern has twice as many green channel samples as red and blue ones, green channel suffers less from aliasing and is the natural choice as the starting point of the CFA interpolation process. In [6], proposed improving red and blue channel interpolation by adding high frequency components extracted from green channel to red and blue channels. In another frequency-domain approach used an alternating projections scheme based [7]

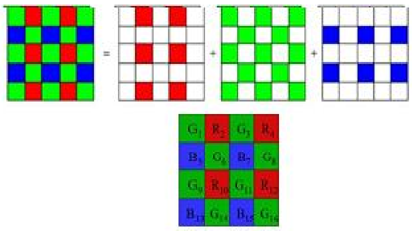


Fig. 1 Bayer CFA pattern

On strong inter-channel correlation in high frequency sub bands. Although the main objective is to refine red and blue channels iteratively, the same approach can also improve green channel interpolation (GCI) beforehand which in turn yields better red and blue channel results. A more recent method [8] makes several observations about color channel frequencies and suggests that filtering the CFA image as a whole instead of individual color channels should preserve high frequency information better. To estimate luminance, the method proposes a fixed 5-by-5 filter at green pixel locations and an adaptive filter for red and blue pixel locations. The estimated full resolution luminance is then used to complete missing the chrominance information. Edge-directed green channel interpolation has been proposed early on with various direction decision rules [4], [5], [9], [10]. The method outlined in [4] is particularly noteworthy because it proposed using derivatives of chrominance samples in initial green channel interpolation. Several subsequent demosaicing algorithms made use of this idea. Authors of [11] proposed using variance of color differences as a decision rule [12] proposed making a soft decision to improve the interpolation performance of the original method [4]. In this method [12], color differences along horizontal and vertical directions are treated as noisy observations of the target pixel color difference and they are combined optimally using the linear minimum mean square - Error estimation (LMMSE) framework. In [13] further improved directional filtering proposed in [12] by introducing scale adaptive filtering based on linear polynomial approximation (LPA). Several methods proposed performing interpolation in both horizontal and vertical directions and making a posteriori decision based on some criteria. In [13] compared local homogeneity of horizontal and vertical interpolation results and in [14] used color gradients over a local window to make the direction decision. In this paper a robust color filter array interpolation technique for color image enhancement is proposed.

2. PROPOSED ALGORITHM:

Step1: The mosaiced image has one of the three color channels available for every pixel location and it certainly does not have complete luminance information at any pixel. The edge strength filter (ESF) can be applied to a mosaiced image by making an approximation. Instead of trying to estimate luminance information and taking estimated luminance differences of neighboring pixel pairs, we take the difference in terms of the available color channel for each pixel pair. For instance, for the red center pixel case the diagonal differences will come from the blue channel and the rest from the green channel.

$$Spr_{10} = \frac{|pb_5 - pb_{15}|}{2} + \frac{|pb_7 - pb_{13}|}{2} + |pg_6 - pg_{14}| + |pg_9 - pg_{11}| \qquad (1)$$

The edge strength for green and blue pixels will be calculated in the same way. The edge strength map obtained from the mosaiced input image will help us both in initial green channel interpolation stage and in subsequent green channel update.

Step2: In this process every green pixel interpolated is marked either horizontal or vertical by comparing the edge strength differences along each direction on a local window. For a window size of 5 by 5, horizontal and vertical difference costs can be formulated as follows:

$$H_{i,j} = \sum_{m=-2}^{2}\left(\sum_{n=-2}^{1} S_{i+m,j+n} - S_{i+m,j+n+1}\right) \qquad (2)$$

$$V_{i,j} = \sum_{m=-2}^{2}\left(\sum_{n=-2}^{1} S_{i+m,j+n} - S_{i+m+1,j+n}\right)$$

Where $S_{i,j}$ is the edge strength filter output at pixel location (i,j), and Hi,j and Vi,j represent the total horizontal and vertical costs, respectively. The target pixel will be labeled horizontal if horizontal cost is less than vertical and vice versa. The rationale behind this decision scheme is that if there happens to be a horizontal edge in a given neighborhood, then the edge strength differences between vertical neighbors will vary more than those of horizontal neighbors. After all the pixels are labeled, the robustness of the direction decision can be improved by relabeling them based on the directions of their neighbors. For instance, considering the closest 8 neighbors of a target pixel and the pixel itself, it will be labeled horizontal only if more than 4 of those 9 pixels are initially labeled horizontal. Based on the final direction label, green channel is interpolated as follows:

$$\tilde{pg}_{i,j}=\begin{cases} pb_{i,j}+\frac{\tilde{pg}^H_{i,j}-pb_{i,j}}{2}+\frac{pg_{i,j-1}-\tilde{pb}^H_{i,j-1}}{4}+\frac{pg-\tilde{pb}^H_{i,j+1}}{4}, \text{if horizontal} \\ pb_{i,j}+\frac{\tilde{pg}^V_{i,j}-pb_{i,j}}{2}+\frac{pg_{i-1,j}-\tilde{pb}^V_{i-1,j}}{4}+\frac{pg_{i+1,j}-pb}{4}, \text{if vertical} \end{cases} \quad (3)$$

where directional estimations are calculated by

$$\tilde{pg}^H_{i,j}=\frac{pg_{i,j-1}+pg_{i,j+1}}{2}+\frac{2*pb_{i,j}-pb_{i,j-2}-pb_{i,j+2}}{4} \quad (4)$$

$$\tilde{pg}^V_{i,j}=\frac{pg_{i-1,j}+pg_{i+1,j}}{2}+\frac{2*pb_{i,j}-pb_{i-2,j}-pb}{4}$$

$$\tilde{pb}^H_{i,j}=\frac{pb+pb_{i,j+1}}{2}+\frac{2*pg_{i,j}-pg_{i,j-2}-pg}{4}$$

$$\tilde{pb}^V_{i,j}=\frac{pb_{i-1,j}+pb_{i+1,j}}{2}+\frac{2*pg_{i,j}-pg_{i-2,j}-pg_{i+2,j}}{4}$$

$$H_{i,j}=\sum_{m=-2}^{2}\left(\sum_{n=-2}^{1} S_{i+m,j+n}-S_{i+m,j+n+1}\right) \quad (2)$$

$$V_{i,j}=\sum_{m=-2}^{2}\left(\sum_{n=-2}^{1} S_{i+m,j+n}-S_{i+m+1,j+n}\right)$$

Green channel estimation for red pixel locations is performed simply by replacing Pb's with pr's in the equations above.

Step3: In This step we update the three color channels by making use of the constant color difference assumption Combined with edge strength filter to improve the initial Green channel interpolation while avoiding averaging across edge structures. For every green pixel to be updated, the closest four neighbors with available color Difference estimates are considered. We expect the edge Strength difference between two pixels to be large across edges. That is why the weight for each neighbor is inversely correlated with the total absolute edge strength difference in its direction. In other words, a neighbor will contribute less to the update result if there happens to be a strong edge between the target pixel and itself. Assuming we are updating the green channel value at a blue pixel.

$$d_1=|s_{i,j}-s_{i-1,j}|+|s_{i-1,j}-s_{i-2,j}|+|s_{i-2,j}-s_{i-3,j}|+c_1$$

$$d_1=|s_{i,j}-s_{i-1,j}|+|s_{i-1,j}-s_{i-2,j}|+|s_{i-2,j}-s_{i-3,j}|+c_1 \quad (5)$$

$$d_2=|s_{i,j}-s_{i,j-1}|+|s_{i,j-1}-s_{i,j-2}|+|s_{i,j-2}-s_{i,j-3}|+c_1$$

$$d_3=|s_{i,j}-s|+|s_{i,j+1}-s_{i,j+2}|+|s_{i,j+2}-s_{i,j+3}|+c_1$$

$$d_4=|s_{i,j}-s_{i+1,j}|+|s_{i+1,j}-s_{i+2,j}|+|s_{i+2,j}-s_{i+3,j}|+c_1$$

$$m_1=d_2*d_3*d_4 m_2=d_1*d_3*d_4 m_3=d_1*d_2*d_4 m_4=d_1*d_2*d_3$$

$$m_{Total}=m_1+m_2+m_3+m_4$$

$$pg_{i,j}=pb_{i,j}+w1*(\tilde{pg}_{i,j}-pb_{i,j})+(w2)*[\frac{m_1}{m_{Total}}(\tilde{pg}_{i-2,j}-pb_{i-2,j})+\frac{m_2}{m_{Total}}(\tilde{pg}_{i,j-2}-pb_{i,j-2})+\frac{m_3}{m_{Total}}(\tilde{pg}_{i,j+2}-pb_{i,j+2})+\frac{m_4}{m_{Total}}(\tilde{pg}_{i+2,j}-pb_{i+2,j})]$$

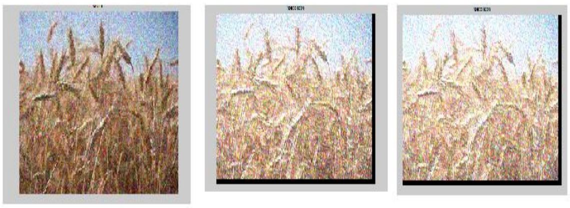
Again, green channel values at red pixel locations are updated in the same way by replacing pb's with pr's in the equations above. $pg_{i,j}$ Stands for updated green channel result while $p\tilde{g}_{i,j}$ is the initial green channel interpolation. c_1 Is a nonzero constant to avoid zero denominator w_1 is the weight for the initial color difference estimation and w_2 is the neighbors' contribution to the green channel update.

3. EXPERIMENTAL RESULTS

In this paper, we evaluate the proposed method by several experiments on different satellite surveying images, and compared the output images of Gaussian, salt and pepper, speckle noises with ground truth images by mean and placed in the tables, drawn the graphs and shown the ground truth , noisy and output images. The existing method median filter will not remove the Gaussian noise. The proposed method confirms the qualitative improvement over the traditional methods. From the tables and graphs it is clear that in any category of images the mean lies in the range of dominant pixels of the image, or between the two or more dominant pixels region. Hence mean evidences the location of object or back ground. The vagueness in the image is Always lies around the edges. The table of values and graph show that the mean of proposed method will always has better quality of output image than mean of the existing method.

3.1. Gaussian noise

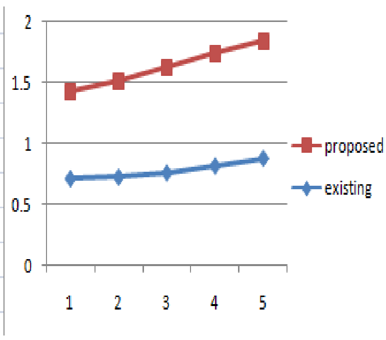
3.1 .1.Gaussian noise for existing method



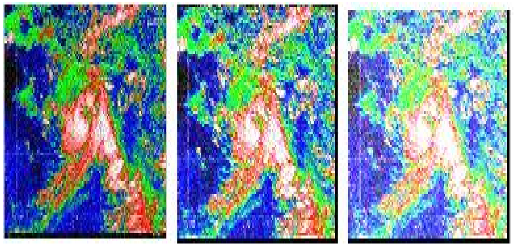
3.1.2. Gaussian noise for proposed method

3.1.3 Graph for Mean values

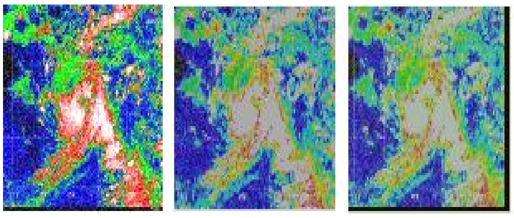
existing	proposed
0.7126	0.7159
0.7259	0.7867
0.7599	0.8698
0.8168	0.9282
0.879	0.9656



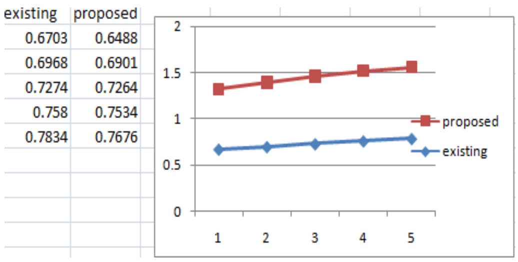
3.1.4 Gaussian noise for existing method



3.1.5. Gaussian noise for proposed method

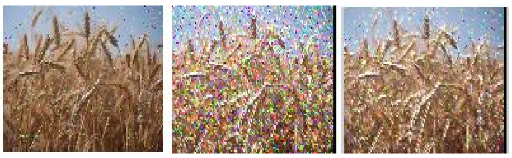


3.1.6. Graph for Mean values

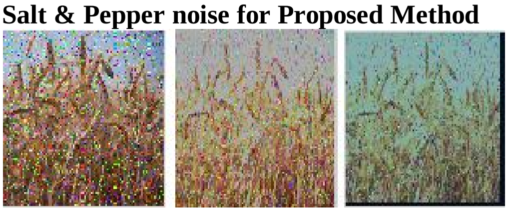


existing	proposed
0.6703	0.6488
0.6968	0.6901
0.7274	0.7264
0.758	0.7534
0.7834	0.7676

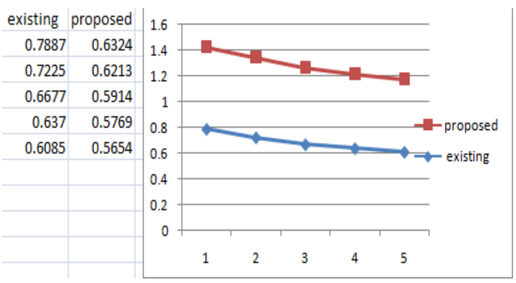
3.2.1. Salt &Pepper noise for Existing Method



3.2.2. Salt & Pepper noise for Proposed Method

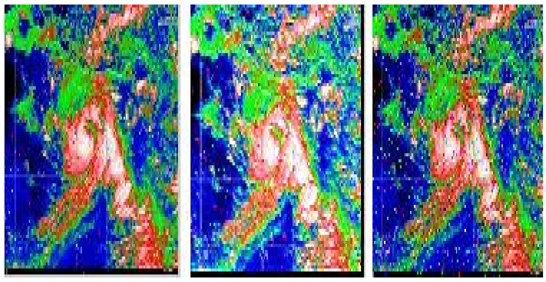


3.2.3. Graph for Mean values

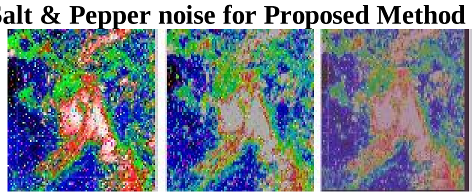


existing	proposed
0.7887	0.6324
0.7225	0.6213
0.6677	0.5914
0.637	0.5769
0.6085	0.5654

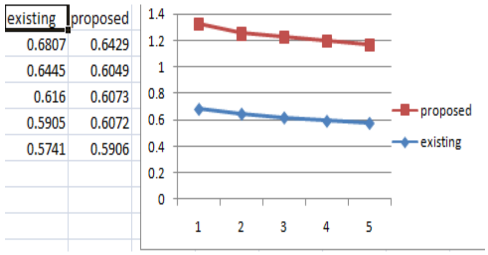
3.2.4. Salt & Pepper noise for Existing method



3.2.5. Salt & Pepper noise for Proposed Method



3.2.6. Graphs for Mean Values

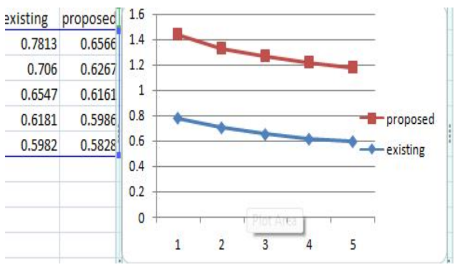


existing	proposed
0.6807	0.6429
0.6445	0.6049
0.616	0.6073
0.5905	0.6072
0.5741	0.5906

3.3.1. Speckle Noise for Existing Method

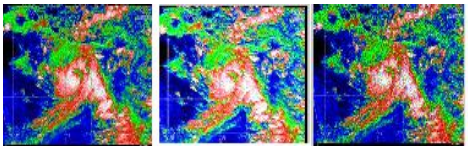
3.3.2. Speckle Noise for proposed Method

3.3.3. Graph for Mean Values

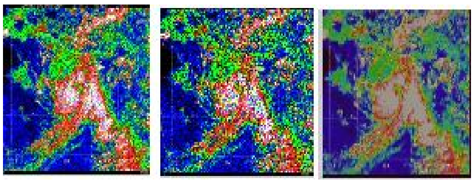


existing	proposed
0.7813	0.6566
0.706	0.6267
0.6547	0.6161
0.6181	0.5986
0.5982	0.5828

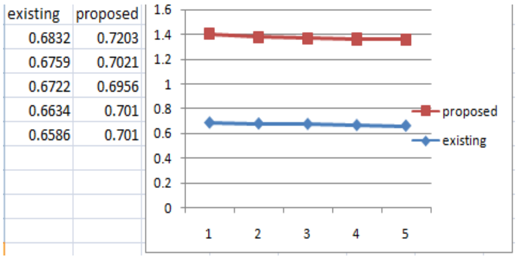
3.3.4. Speckle Noise for Existing Method



3.3.5. Speckle Noise for Proposed Method



3.3.6. Graphs for Mean Values



existing	proposed
0.6832	0.7203
0.6759	0.7021
0.6722	0.6956
0.6634	0.701
0.6586	0.701

4. CONCLUSION

The Experimental results which we have taken for different set of test images. Here the performance of green channel is updated and improved by making adaptive for each pixel by checking the total absolute difference between the closest known green pixels. Here we applied this method for three different noises salt & pepper, speckle, and Gaussian noise. The noises have been eliminated by using this proposed method.

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AUTHORS

Suma Chappidi received her B.Tech, Degree in Electronics and Communication Engineering and currently pursuing M.Tech at Rise Krishna Sai Gandhi Group of Institutions, Ongole, Andhra Pradesh, INDIA. Her main research interest includes Enhancement, Pattern Recognition and Image Processing.

Sandeep Kumar Mekapothula iscurrently working as Assistant Professor in the department of ECE at Rise Krishna Sai Gandhi Group of Institutions, Ongole, Andhra Pradesh, INDIA. He has received B.Tech, Degree in Electronics and Communication Engineering. His main research interest includes Segmentation, Image Enhancement, Pattern Recognition and Image Processing.