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Demosaicing Techniques Thorough Analysis

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ABSTRACT: Facsimile Demosaicing is a significant effort in various facsimile processing and computer vision problems. There are numerous prevailing approaches for Demosaicing of facsimile. The imperative characteristic of a fine facsimile Demosaicing prototype is that it must entirely eliminate fuzziness as much as probable. It should also reserve edges. This work inhibits a summary of certain key performances in the area of facsimile Demosaicing techniques. There are numerous distributed procedures and all methods have their molds, benefits, and limits. After a concise overview numerous approaches have been illuminated for eliminating fuzziness from the facsimile.

KEYWORDS: Facsimile Demosaicing

I. INTRODUCTION

With the increase in the volume of digital Facsimiles captured every day, the requirement for extra accuracy and graphically attractive Facsimiles has been rising. Though the Facsimiles are taken by the advanced cameras are unavoidably corrupted by fuzziness and which causes worsened visual Facsimile excellence. Consequently, some methods are needed to decrease fuzziness without dropping any feature of the facsimile. Till now, academicians have suggested many approaches for lessening fuzziness. All techniques have their benefits and drawbacks. In this article, we have summarized a few significant works in the area of Facsimile Demosaicing. Moreover, we have discussed the features of these methods. Conclusively, we have provided many favorable ideas for upcoming research. Given that most raw recordings only capture a single-color value for each pixel in a picture, the method of determining the missing color values for every pixel in a raw picture is known as Demosaicing. Most digital cameras' sensors only store one color value for each pixel when you capture in raw mode. For instance, the "Bayer pattern" is used by many digital cameras' sensors to represent color values. In this setup, there will be two pixels that only capture the green color value for each set of four-pixel values, one pixel that only records the red value, and one pixel that only records the blue value. Hence, when turning a raw capture into an actual image file, part of the process involves figuring out the "missing" color values for every pixel. "Demosaicing" is the term used to describe that technique. Fig 1 shows the missing color values and how a Demosaicing process can determine it through neighboring values.

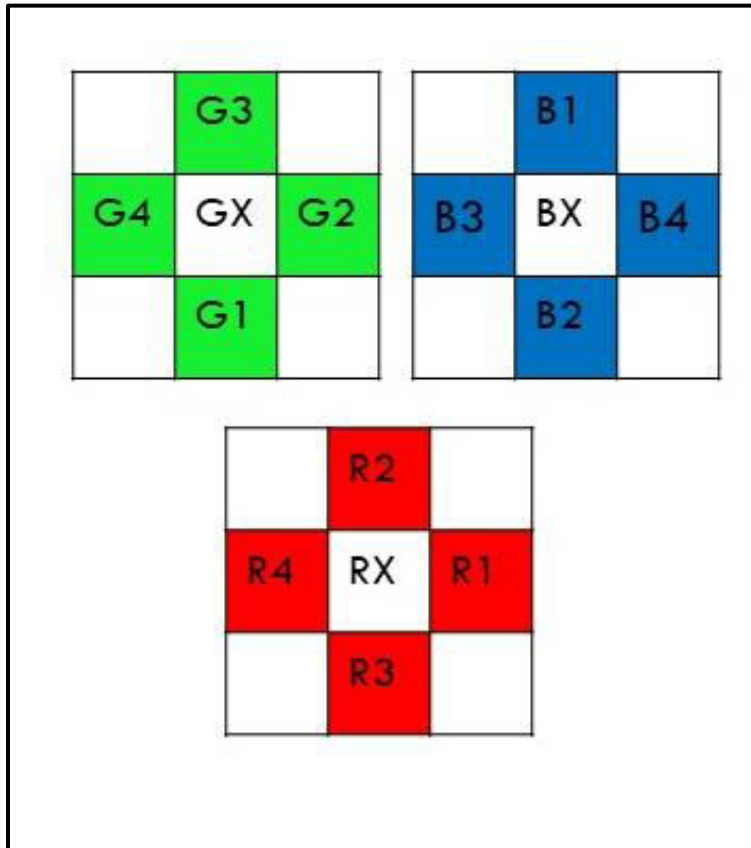


Fig 1: Demosaicing to determine the missing values

II. RELATED WORK

The captured images can be damaged due to various environmental effects like light, pose, or damaged camera, etc. The authors in [1-4] have suggested various Image Denoising approaches to enhance the quality of an image. The quality and sharpness of an image can be amplified through an approach suggested by authors in [5-6]. Furthermore, the damaged part of an image can be restored through image inpainting methods [7-8].

A digital camera uses a variety of processing techniques throughout the image capturing process, such as auto-focus, white balance adjustment, color interpolation, color correction, and compressing. Color filter array (CFA) interpolation, or the process of recovering a complete picture from its CFA data, is a crucial part of the imaging workflow. Every pixel position needs to have a minimum of three different color samples in order to build a color photo. Using beam-splitters along the beam axis to create the picture onto three different sensors is one method. Three full-channel color pictures are generated by placing a color lens in front of each sensor. This method is expensive since it calls for three charge-coupled devices (CCD) sensors, which must also be precisely aligned. Using a color filter array (CFA) in front of the sensor to record one color component per pixel and then extrapolate the two missing color elements is a more economical method. Due to the obvious CFA's mosaic pattern, this interpolation technique is frequently referred to as Demosaicing [9].

The Bayer pattern [10] assesses the red and blue pictures on rectangular grids (1/4 of the image resolution) and the green picture on a quincunx grid (1/2 of the image resolution). The human visual system's sensitivity is in the



medium wavelengths, which correlate to the green region of the spectrum, hence the green channel is monitored at a higher sample rate than the other two.

III. DEMOSAICING APPROACHES

Sequential Demosaicing Approaches

The luminance (Green) channel is less inducing than the other two, which is the primary driver behind the sequential method. Consequently, the restoration of chrominance (Red/Blue) ones is facilitated by having a full-resolution luminance. Due to the obvious error propagation in sequential techniques, it appears that the correctness of the first stage is essential to the entire performance. As a result, much effort has been made to increase the spatial and frequency domain precision of luminance channel interpolation.

Sensitive Edges Approaches

Since the green color factor in a CFA picture is estimated before the red and blue color elements, its precise reconstruction is crucial. Errors in the reconstruction of the green components will also lead to an inaccurate estimate of the other two factors. Hence, the spectral correlation makes use of spatial correlation to improve the precision of green element restoration. The key problem is estimating the edge direction from CFA, but interpolation along edges using color ratios or color differences typically reduces color artifacts. The red and blue elements are filled in by red to green and blue to green ratios after the green element is rebuilt using bilinear interpolation. The color ratio approach is typically used, although other reconstruction algorithms additionally make use of the variation in color components [11]. Adaptive interpolation is used for edge interpolation in [12]. The chrominance and brightness differences in an image's horizontal and vertical directions are calculated to create the gradient values, which are then compared with a threshold value to determine the interpolation direction. In [13], median filter and spatial deinterlacing are used for edge estimation, providing accuracy and artifact suppression. Additionally, a method that is adaptive [14] is used to estimate the green samples based on the variation of the color difference along the direction of the edges. This method helps to lessen color artifacts while maintaining the textural details. An iterative Demosaicing technique for color channel estimation is reported in [15] and is based on color difference and weighted edge interpolation.

Frequency Domain Approaches

Frequency domain analysis was also applied in a few of the image Demosaicing approaches. Typically, it entails splitting a picture into the spectral analysis that needs to be adjusted while converting a mosaic picture into the frequency domain. Red and blue color channels are sampled at slower rates, so some high frequencies cannot be produced by utilising interpolation methods that are typically used. The author offered an interpolation technique in [16] to address this problem by combining subsampled red and blue pictures with high-frequency knowledge from the green channel. Additionally, it offers a means to lessen distortion brought on by aliasing. In [17], frequency domain-based CFA with limited optimization is used to get efficient outcomes by lowering the Demosaicing errors. By choosing the geometrical points on the surface of a convex polyhedron or polygon, the optimization problem is reformulated to decrease the number of parameters and speed up the process of searching for parameters. Authors in [18] suggest a different strategy based on the least-squares method for bandpass filters in the frequency domain. Moreover, in [19], a multi-objective optimization approach is used to minimise the overlap between the frequency components of mosaicked pictures, where the parameter is optimised based on a restricted optimization problem to minimise the visual artifacts.

Directional Interpolation Approaches

In [20], the red and blue channels are estimated with each green color component after the FIR filter reconstructs the green color channel in horizontal and vertical orientations. Based on the local homogeneity of a picture, the Demosaiced picture is chosen from the two interpolated pictures; specifically, the direction of interpolation that gives a more homogenous neighbourhood around the considered pixel is chosen. In [21], the interpolants are



obtained using cubic spline interpolation and a Taylor series-based technique in each of the four opposing directions. The output with the preserved edges is created using the weighted median filter, whose coefficients are derived from the edge orientation map. Bilinear interpolation is used by authors in [22] to calculate the luminance element twice, which aids in the final interpolation. [23] estimates the missing color sample in a variety of local directions before fusing it in line with the regional gradients. For enhancing the local estimate, adaptive thresholding is preferable over nonlocal means filtering.

Spatial-domain Approaches

Due to the significance of the green channel, more advanced edge-directed or sensitive interpolation techniques later emerged. Based on geometrical duality, local covariance can be calculated and used to modify the interpolation [24]. Demosaicing by optimal recovery, which conceptualises the interpolation of the Green channel by a patch-based quadratic optimization process, is a strongly linked piece of work [25]. Computing the Jacobian matrix of the color map and neighbourhood voting are additional methods for achieving spatial adaptation. Another advanced method interpolates the absent green pixels using a weighted sum, where the weight allocations are influenced by the local gradients of the Green and Red/Blue channels [26].

Discrete Wavelet Transform Approaches

Demosaicing techniques included using the Discrete Wavelet Transform (DWT), which divides a picture into four sub bands—LL, LH, HL, and HH—based on low pass and high pass filters. In LL, both rows and columns are low pass filtered; in LH, rows are low pass filtered and columns are high pass filtered; in HL, rows are high pass filtered and columns are low pass filtered; and in HH, both rows and columns are high pass filtered. It has been established that these sub bands exhibit substantial correlation across multiple color channels, making it possible to restore other sub bands using the data from sub bands in one color channel [27]. To lessen the impacts of zipper and aliasing, the method interpolates three color channels using DWT. For every channel, it used wavelet coefficient interpolation, which was afterward combined to provide an interpolated image. Similar to this, the authors in [28] assess the missing channel made use of wavelet sub bands, where the high-frequency sub-band was estimated using the inter-channel data by taking the CFA pattern into account, while the low-frequency sub-band was generated using intra-channel data. In [29], wavelet transform is used for Demosaicing in order to preserve color information while improving spatial resolution by combining the luminance image with interpolated R, G, and B pictures.

Machine Learning Based Approaches

The Demosaicing process was carried out by the authors of [30] utilising a sparse model that was further optimised by the radial basis function. Convolutional Neural Networks (CNN) are used in [31] to Demosaic images, first creating a basic Demosaiced picture with color artifacts and then refining it via deep residual estimation and multi-model fusion. In [32], a method is proposed to carry out the tasks of image denoising and Demosaicing using machine learning, CNN, and deep residual networks, which delivered greater details along with the suppression of noise and artifacts. An adaptive residual U-net is additionally offered in [33] for the Demosaicing application, substantially reducing artifacts in a picture's textural region.

Renewal Approaches

Approaches to image restoration are typically employed for Demosaicing. To address problems with polychromatic sampling, the authors in [34] provided the best reconstruction techniques based on the Bayesian technique for an estimate. This method is expanded upon in [35] by using a sharpening algorithm to reduce the sharpness of a picture that develops during Demosaicing. In addition to MRF, the authors in [36] also offered a Bayesian technique that enhances the integrity of the recreated image, particularly its edges.



IV. CONCLUSION

The Bayer CFA pattern is the primary subject of this paper's analysis of the Demosaicing problem. This study examines many sorts of image Demosaicing approaches. Recent research that used learning-based Demosaicing algorithms showed encouraging results when compared to older methods. Since eliminating the zipping and colorartifacts during Demosaicing is a frequent challenge. Therefore, the majority of techniques seek to lessen these artifacts to enhance their performance. Some of the approaches also incorporate the use of Demosaicing in addition to denoising and super-resolution. As a result, unified techniques can be implemented to carry out numerous jobs with less complexity.

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