International Journal of Latest Trends in Engineering and Technology
Special Issue - International Conference on Nanotechnology: The Fruition of Science-2017,*pp.110-112*
e-ISSN:2278-621X, p-ISSN: 2319-3778

DIRECTIONAL DEMOSAICKING FOR DIVISION OF FOCAL PLANE POLARIZATION

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Abstract:-The digital camera is mostly composed of a 2D grid of varied imaging sensors. The state of art polarization imaging consists of four pixilated polarization filters, called the Division of Focal Plane (DoFP) polarization sensors. The sensor acquires only a subset of the information leading to the loss of spatial resolution. The division of focal plane integrates micro polarizers with focal plane. This imaging sensor reduces the spatial resolution and each pixel has varying Instantaneous Field of View (IFoV) such setback can be overcome by several demosaicking algorithms which is an important segment in image processing. The reconstruction of the missing information is standardized by the process of demosaicking. We propose a new directional demosaicking in division of focal length plane polarization in which the missing polarization values are estimated directionally. It can effectively reconstruct the spatial resolution of the polarization imaging sensor.
Keywords:Division of Focal Plane (DoFP), Instantaneous Field of View (IFoV), demosaicking, polarization.

I. INTRODUCTION

The primary properties of light include intensity, wavelength and polarization. The first and the second property are determin ed as brightness and color whereas the third property is not given much significance in imaging technology with reference to the human visual perception. The advancement in nanotechnology leads to the surfacing of polarization imaging sensors. Every imaging frame consists of polarization properties of optical field in high resolution captured by the sensors. The commonly used CMOS (Complementary Metal Oxide Semi-Conductor) and CCD (Charge Coupled Device) cameras [1,2] capture only the first and the second property while the third property is completely neglected. The third property (i.e.)polarization provides the details about the transverse electric field orientation.

The current development in nanofabrication and nano-photonics enabled the development of compact and high resolution polarization sensors known as Division of Focal Plane (DoFP)Polarimeters.It monolithically integrates pixilated metallic nano-wire filters that acts as a polarization filters with an array of imaging elements [3]. The bayer color filter is integrated with an array of CMOS/CCD pixels [4] while in DoFP the optical elements are monolithically integrated with photo sensitive elements. The DoFP includes imaging elements photo detectors and micro-polarization on the same plane and documents the first three or four Stokes parameter at every frame [5,6].

The micro-polarization filter array is composed of pixelated polarization filters leaning at several different angles to filter the incident optical field and placed in the imaging plane, thus the spatial resolution is lost to a great extent in the red green and the blue channels. The use of demosaicking methods has been persistently increasing over the last few decades for the betterment of the color replication accuracy and for better reconstruction of the missing spatial resolution [7,8]. Demosaicking plays a major role in the acceptance of color imaging, it reconstructs the image by estimating the missing spatial components as the filter captures only a subset of the information as shown in Fig.1 [9].

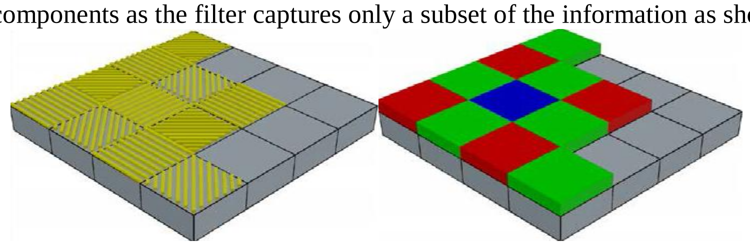

Fig. 1 Block Diagram of Division of Focal Plane in Polarization Sensor and Color Sensor with BayerColor Filter Array

The polarization sensor is composed of a collection of 2 by 2 pixels or super pixels it uses the four pixelated polarization filters whose transmission axis is offset by 45 degree from each other and consists of only ¼ of the linear polarization information. The four pixels are spatially close to each other but the Instantaneous Field of View(IFoV) is different resulting in varied intensity values. Reconstruction of the polarization information is done on the basis of the pixel intensities such as Strokes vector [5], angle of degree of linear polarization. The conventional demosaicking algorithmsinclude bilinear and bi-

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cubic interpolation [9], gradient interpolation [10] denoising techniques are also combined with the demosaicking algorithm using Gaussian processes [11] and using the intensity correlation [12].
A new directional demosaicking algorithm is proposed to demosaic the image taken by a DoFP polarization sensor in which the missing polarization values are estimated directionally. Directional demosaicking effectively reconstructs the polarization information by estimating the missing spatial information. The directional demosaicking can effectively reconstructs the spatial resolution of the polarization imaging sensor based on the threshold value.
The rest of the paper is structured as follows section II compares the polarization demosaicking and color filter array demosaicking,section III explains the proposed work, section IV concludes the paper.

II. COMPARISON OF COLOR FILTER ARRAY DEMOSAICKING AND POLARIZATION DEMOSAICKING

The demosaicking algorithms are the most commonly used technique in image processingin the preceeding decade. Demosaicking in general is explained as the process of reconstructing a raw image into a full color image in color sensor. A color sensor uses a color filter array to filter the image, constructing a raw image with only one channel in each pixel location. The filter array most commonly used in color sensor is the bayer color filter array as in Fig.1. The bayer color filter consists of half the green channels than the red and the blue color channels Demosaicking recovers the missing data in each channel and reconstructs a high resolution image from a low resolution raw color image.
In polarization, demosaicking the DoFP sensor is infrared or visible spectrum as in Fig.1 consisting of pixilated polarization filter. A neighborhood of 2 by 2 pixels called super pixel is considered, where four polarization filter offset by 45 degrees are deposited in individual photo receptors. Four different sub-sampled images are produced due to different IFoV, large errors are produced in polarization information and is reconstructed approximately into high resolution by demosaicking. Although some of the color demosaicking algorithms can be shifted to polarization imaging sensors, its mandates a new research direction in polarization demosaicking.

III. PROPOSED WORK

A. Outline

In the proposed workdemosaicking is applied on the polarization information. The DoFP sensor acquires the polarization information and the intensityvalues. The optical field of these two constraints is computed using the sub-sampled image with 0^o,45^o,$90^o$and 135^o polarization filters. The polarization constraints rely on the Angle of Polarization (AoP) and the Degree of Linear Polarization (DoLP), they are computed as

$$Intensity = (1/2)\cdot\left(In(0^o) + In(45^o) + In(90^o) + In(135^o)\right) \quad (1)$$

$$DoLP = \sqrt{\frac{\left(In(0^o) - In(90^o)\right)^2 + \left(In(45^o) - I(135^o)^2\right)}{Intensity}} \quad (2)$$

$$AoP = (1/2)\cdot \arctan\left(\frac{\left(In(45^o) - I(135^o)\right)}{\left(In(0^o) - In(90^o)\right)}\right)$$

where, In is the intensity values of the polarized image in the followng angles 0^o,45^o,90^o,135^o. The demosaicking process reconstructs the polarized image by directional estimation of the spatial resolution and demosaicks based on the threshold value.

B. Directional Demosaicking

The demosaicking is done in four directions. The directional estimation of the missing spatial information was commonly used among several demosaickng algorithms on color sensor images. The directional estimate is based on the intensity values of the pixel. The four pixelated polarization filter produces four sub-sampled image.The demosaickng process is done in four directions depending on the intensity values of the polarized image. The demosaicking process produces artifacts when computing new pixel across the edges. An edge is a place where there is starting of one pixel and ending of another, it is were the gradients exceed beyond the threshold value. The edges are determined by different angles and degrees of linear polarization. A 7 x 7 low pixel resolution neighbourhood on all four images are evaluated by the equation.

$$\begin{cases} Dir_{0^o} = \sum_{x=2,4,6} \sum_{y=3,5,7} |In(x,y) - In(x,y-2)| \\ Dir_{45^o} = \sum_{x=1,3,5} \sum_{y=3,5,7} |In(x,y) - In(x+2,y-2)| \\ Dir_{90^o} = \sum_{x=3,5,7} \sum_{y=2,4,6} |In(x,y) - In(x-2,y)| \\ Dir_{135^o} = \sum_{x=1,3,5} \sum_{y=1,3,5} |In(x,y) - In(x+2,y+2)| \end{cases} \quad (4)$$

In Eq.4 Dir 0^o indicates the estimate in horizontal direction, Dir 90^o indicates directional estimate vertically followed by the diagonal estimation in Dir 45^o and Dir 135^o. After obtaining the directional estimates of the pixel, directional demosaicking is applied to the image with reference to the threshold (T) value which is set to 1.2 in our case.

Demosaicking in general starts with the green channel in a color sensor due to high sensitivity of human visual perception and in diagonal crossing point in a DoFP sensor, if Dir 45^o/Dir 135^o> T, then there is a presence of edge along 135^o and directional demosaicking is applied in 135^o direction. If Dir 135^o/ Dir 45^o>T, then demosaicking is done along the Dir 45^o direction. In the second step the horizntal and vertical points are considered, if Dir 0^o/Dir 90^o>T demosaicking is applied in the 90^o direction due to the presence of an edge along 90^o. If Dir 90^o/Dir 0^o>T demosaicking is done in 0^o. The remaining cases in the target pixel will be averaged to its four adjacent pixels in the respected directions either vertically, horizontally or diagonally.

C. Algorithm:

Input : Image obtained from a DoFP polarization sensor.
Output : Demosaicked Image.
Step 1 : Directional estimates is obtained in four directions 0^o,45^o,90^o,135^o
Step 2 : Demosaicking is applied based on the threshold value 1.2.
If Dir 45^o/Dir 135^o> T demosaickingis in 135^o direction.
If Dir 135^o/ Dir 45^o>T demosaicking is in 45^o direction. If Dir 0^o/Dir 90^o>T demosaicking is in 90^o direction.
If Dir 90^o/Dir 0^o>Tdemosaicking is in 0^o direction.
Step 3 : Target pixel is averaged for four adjacent pixels in the respected direction obtaining a demosaicked image.

IV. CONCLUSION

A theoretical framework of a new directional interpolation in DoFP sensor is presented in this paper. The demosaicking algorithm reconstructs the polarized sensor image by directionally estimating and finding the missing spatial components in four directions based on the threshold co-ordinate. The results of polarization demosaicking would produce accurate reconstruction and high resolution images.

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