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Image Authentication by Detecting Demosaicing

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Abstract: In this digital world we come across many image processing software that produce doctored Images with high sophistication, which are manipulated in such a way that the tampering is not easily visible to naked eye. The authenticity of a digital image has become a challenging task due to the various tools present in the photo editing software packages. There are number of ways of tampering an Image, such as splicing two different images together, removal of objects from the image, addition of objects in the image, change of appearance of objects in the image or resizing the image. This Image authentication technique detects traces of demosaicing in the complete absence of any form of digital watermark or signature and is therefore referred as passive. So there is a need for developing techniques to distinguish the photographic image from the Photorealistic Computer Generated Image, the genuine ones from the doctored ones. Estimation of demosaicing parameters is not necessary ;rather ,detection of the demosaicing is important.

Index Terms: photorealistic computer generated images (PRCG), photographic images (PIM), Demosaicing, Color Filter Array (CFA).

I. INTRODUCTION

Research on computer graphics has recently received an enormous interest throughout the whole multimedia security community and even beyond. Human have difficulty in identifying photorealistic images generated from computer and photographic images. A wide distribution of digital cameras, in combination with sophisticated editing software, has driven the development of a large number of forensic tools that can assess the authenticity of digital images without access to the source image or source device.[1, 2] One particular class of forensic methods relies on characteristic local correlation pattern due to demosaicing in typical digital cameras[.3,4] Most cameras capture color images with a single sensor and an array of color filters. As a result, only about one third of all pixels in an RGB image contain genuine information from a sensor element. The remaining pixels are interpolated. While early forensic techniques merely assumed the existence of demosaicing-induced correlation between neighboring pixels, more recent methods can also infer information about the underlying structure of the color filter array as well as the demosaicing algorithm.

II. RELATED WORKS

Image processing is often not necessary for image manipulation detection. For instance, a picture supposed to be taken in India that shows the China monument in the background will be suspect by inspection. Detection of incongruous textural features, however, may require substantial image processing. The manipulation are sometimes not noticeable by human eye, they do affect the statistics of the image, because of detection of tampering is possible. Thus it becomes very important to develop efficient techniques which may detect these forgeries which are addition of an object in image, removal of object from image and change of appearance of the object in image. The process of Image morphing detection can involve several works. These work include, but are not limited to, evaluation of image structure issues include discovery of artifacts consistent with image manipulation or degradation, metadata analysis, and indications of provenance and Image content issues include continuity issues, evidence of manipulation, evidence of staging, and misplacing. There are several possible techniques for detecting manipulation in the source of a digital image. Image can be authenticated by Digital watermarking. Digital watermarking has two classes of watermarks, fragile and robust. Robust watermarks techniques are designed to be detected even after attempts are made to remove them. Fragile watermarks techniques are used for authentication purposes and are capable of detecting even minute changes of the watermarked content. But, neither type of watermark is ideal when considering "information preserving" transformations (such as compression) which keep the meaning or expression of the content and "information altering" transformations (such as feature replacement) which modify the expression of the content.

The drawback of watermark techniques is that one must embed a watermark into the digital image first. Also a watermark must be inserted at the time of capturing the image, which would limit this approach to specially equipped digital cameras. Many other techniques that work in the absence of any digital watermark or signature have been invented. The set of image forensic tools for passive or blind approach for image manipulation detection can be roughly categorized as pixel-based techniques, format based techniques, camera based techniques geometric based techniques. In this paper we discuss presence of demosaicing in image (It may be Photorealistic Computer Generated Image(PRGC) or Photographic Image(PIM)).

III. COLOR FILTER ARRAY AND DEMOSAICING ALGORITHM

A color filter array is made of color filters in front of the image sensor. Nowadays, the most commonly used CFA

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configuration is the Bayer filter illustrated here. This has alternating red (R) and green (G) filters for odd rows and

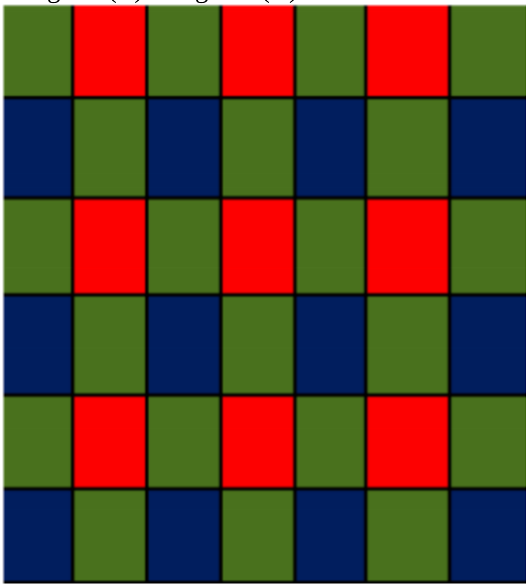

Figure 1: The Bayer arrangements of color filters on the pixel array of an image sensor. Each two-by-two cell contains two green, one blue, and one red filter.

Alternating green (G) and blue (B) filters for even rows. There are twice as many green filters as red or blue ones, catering to the human eye's higher sensitivity to green light. Since the color sub sampling of a CFA by its nature results in aliasing, an optical anti-aliasing filter is typically placed in the optical path between the image sensor and the lens to reduce the false color artifacts (chromatic aliases) introduced by interpolation. Since each pixel of the sensor is behind a color filter, the output is an array of pixel values, each indicating a raw intensity of one of the three filter colors. Thus, an algorithm is needed to estimate for each pixel the color levels for all color components, rather than a single component.

A demosaicing algorithm [5,6,7] is a digital image process used to reconstruct a full color image from the incomplete color samples output from an image sensor overlaid with a color filter array (CFA). It is also known as CFA interpolation or color reconstruction.

Most modern digital cameras acquire images using a single image sensor overlaid with a CFA, so demosaicing is part of the processing pipeline required to render these images into a viewable format. Many modern digital cameras can save images in a raw format allowing the user to demosaic it using software, rather than using the camera's built-in firmware.

A demosaicing algorithm has alias name called color filter array interpolation and it is applied to the raw digital image to calculate the pixel value for each color component. There are two possibilities of interpolation that can be either be linear or adaptive.

Each color channel is interpolated separately using only samples from the same color in native interpolation, for example, with bilinear interpolation.

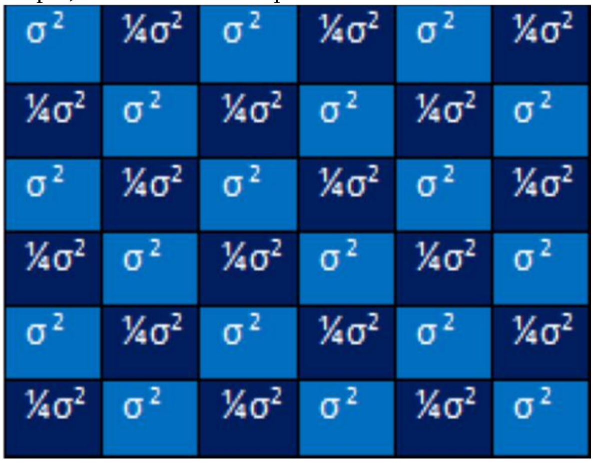

Fig 2 When demosaicing is performed with linear interpolation, the original blue pixels have higher variance than the interpolated blue pixels. The spatial pattern of variances is the basis for detecting the presence of demosaicing. The blue photosites pixel values in the Bayer array are IID with variance σ2 , the above image shows the variance from which each pixel value is drawn.

By considering only the pixel values of the Bayer pattern shown in Figure 1, each missing blue pixel value can be interpolated from its four nearest neighbors using bilinear interpolation:

$$\hat{b}(x,y)=\frac{1}{4}\begin{bmatrix}1 & 1 & 1 & 1\end{bmatrix}\begin{bmatrix}b(x-1,y)\\ b(x,y-1)\\ b(x+1,y)\\ b(x,y+1)\end{bmatrix} \text{..........(1)}$$

Considering that the original blue pixel values are IID and estimated from a normal distribution with variance σ2, the estimated blue pixel values can be shown to have a variance of only 1/4 σ2 . As the figure 2 show, the blue channel is divided into two interleaved quincunx patterns, one similar to the original blue pixel locations, and the other similar to the calculated blue pixel locations with lower variance. This analysis oversimplifies the demosaicing and for the purpose of illustration this skips the nonlinear image processing. Here the vital point to understand is that demosaicing introduces periodic patterns into the image signal.

IV. THE PROPOSED SCHEME

Combining the neighboring pixel values, an interpolated pixel value is generated. The variance gets affected by the weight of the neighboring pixels which produce an interpolated pixel value. This forms the pattern of variances which can be detected and serves as the basic idea for detecting demosaicing. For demonstrating our approach we consider channels of only specific color while use of any channel is permitted during actual system implementation. Figure 3 shows the basic flow of our approach. First high pass operator h(x,y) is operated on the

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image i(x,y) and low frequency information is removed from it. When demosaicing occurred, embedded periodicity is also enhanced. Operator selection is done:

$$h(x,y) = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix} \qquad (2)$$

Following figure shows the flow diagram for Photo Morphing Detection:

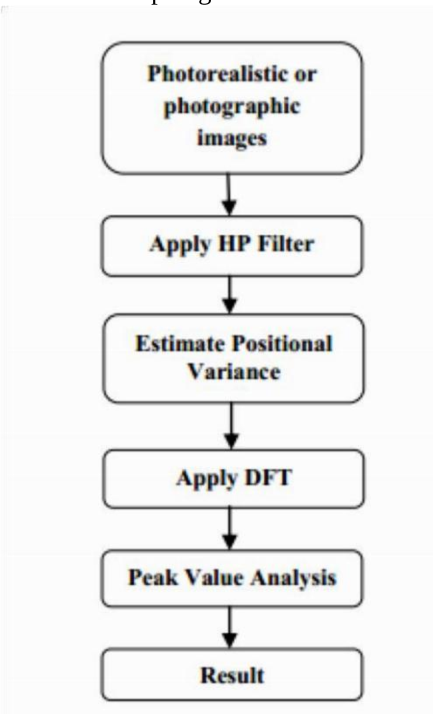

Fig 3: Flow diagram for Photo Morphing Detection. First photographs from digital cameras or computer generated images are given to high pass (HP) filter. Then HP Filter is applied, and then the Positional Variance of each diagonal is calculated. Then DFT is used to find periodicities in the variance signal, then Peak Value is analyzed, indicating the presence of demosaicing in the image.

The variance of the output of operator can be found from a distribution with variance σ2 . If we again make the simplifying assumption that the channel is interpolated with linear interpolation:

$$\sigma_0^2 = 4(\frac{1}{4})^2 \sigma^2 + 4(\frac{1}{2})^2 \sigma^2 + (1-4)^2 \sigma^2 \qquad (3)$$

$$\sigma_0^2 = \frac{41}{4} \sigma^2 \qquad (4)$$

$$\sigma_i^2 = 0\,\sigma^2 \qquad (5)$$

$0\sigma^2$ the variance of the output of application of h(x,y) at positions corresponding to original photosites in the image sensor, and thus nine pixel values from the original sensor contribute to the filter output and four with a coefficient ¼, four with a coefficient ½, and position (x, y) itself has coefficient -3.σ_i^2 Corresponds to locations where the blue Corresponds to locations where the blue value is interpolated by considering the blue channel is interpolated with linear interpolation. In case, if missing blue values were actually estimated with linear interpolation and all other image processing operations in the camera are ignored, then application of the filter h(x, y) yields a value of zero at each pixel location with an interpolated blue value. The choice of h(x, y) was made to maintain a large value for $0\sigma^2 / \sigma_i^2$ and testing using a small number of training images. A large ratio of $0\sigma^2 / \sigma_i^2$ aids in the detection of the periodic pattern of variances characteristic of demosaicing.

Our test images are different from the demosaicing operated images. Test images are finished images from real consumer cameras. Demosaicing is performed on nonlinear filter and the image processing path contains various activities such as noise suppression, image enhancement etc.

After that, estimate of the variances is calculated using the method called Maximum Likelihood Estimation (MLE). The statistical variance of the pixel values along each diagonal is found to compute the MLE estimation of variance.

This projects the image down to a single dimension signal,m (d),Where m(d) represents the estimate of the variance corresponding to the d^{th} diagonal:
in the frequency spectrum of m(d).

$$m(d) = \frac{\sum_{x+y=d} |h(x,y) * i(x,y)|}{N_d} \qquad (6)$$

$\omega = \Pi$ Generally, interpolated images do not contain a peak Where, N_d is the number of pixels along the d^{th} diagonal and is used for normalization.

V. EXPERIMENTS

To find the periodicity in m(d), the DFT is computed to find **Our approach validate for :** distinguishing PIM from $|M(e^{j\omega})|$.

A relatively high peak at frequency $\omega = \Pi$ indicates that the image is not morphed and it is the PRGC and accurately localizing tampered image regions.

We emphasize that all of our photographic images are characteristic of demosaicing.

The peak magnitude at compressed JPEG images directly from the camera. is calculated as: Therefore they have undergone real-world demosaicing, nonlinear rendering, and JPEG compression.

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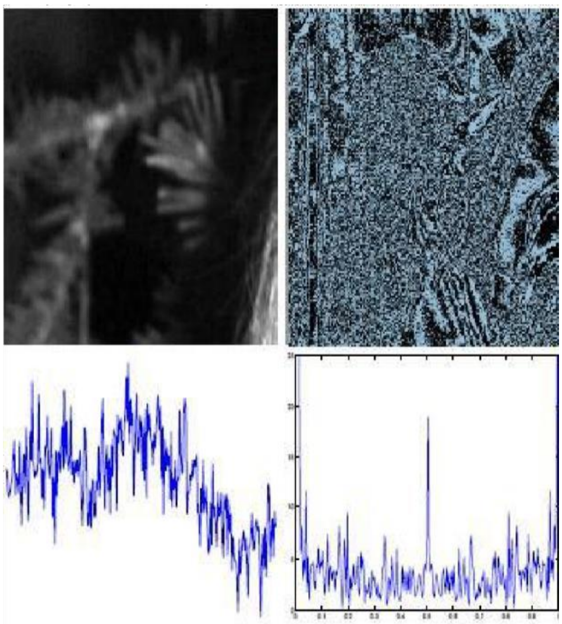
$\omega = \Pi$

$$s = \frac{|M(e^{jw})|_{\omega=\Pi}}{k} \quad (7)$$

$\omega = \Pi$



Distinguishing PIM from PRCG

Where high peak value at frequency ω and k is is We use Columbia's ADVENT dataset from [8]. This set the median value of the spectrum, by omitting the DC contains 2400 images, including 800 personal PIM from the value. Normalizing by k was found to be vital to authors of [8] and Philip Greenspun (*personal*), 800 differentiate between true image and images containing PIMfrom Google Image Search (*google*), and 800 PRCG signals with large energy across the frequency spectrum. from various 3D artist websites (*CG*). In our work, we omit

the *google* images because their origin is not well known (i.e., it appears many have been resized).The images contain a wide variety of subjects such as people, animals, objects, and architecture. Samples of both PIM and PRCG are shown in Figure 5 and Figure 6. Resp. For each image, the score s is computed as described in Section 4. An image is classified as PIM if its value s exceeds a threshold t, and as PRCG otherwise. By varying

Fig 4: Distinguish between images containing noise with large energy across the frequency spectrum and true demosaicing signals generated by our algorithm. Bottom Left: The signal m(d), which represents an calculation of the variance along each image diagonal. Bottom Right : The spectrum of m(d), represents the characteristic peak at example.

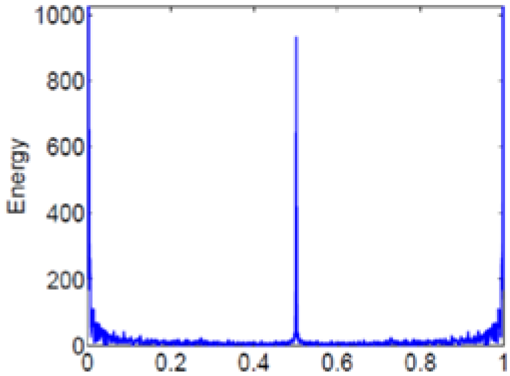


Figure 5 .PIM Image example.

Normalized Frequency

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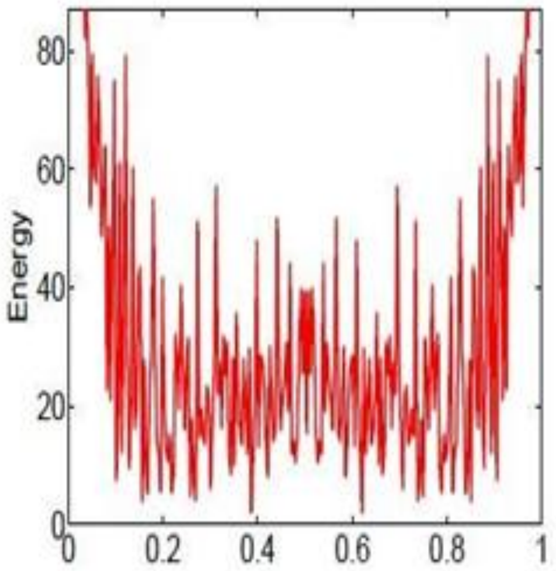

Figure 6 .PRCG Image example.

performance curves are generated. Figure 7 shows the result of our experiments.

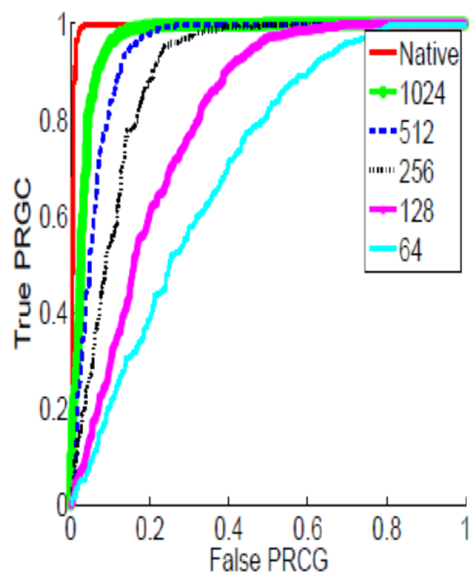

Figure 7. The performance of our algorithm for distinguishing between photographic images and photorealistic computer graphics from the ADVENT dataset [8]. Each curve reports the performance using only a central square window of a specific size of pixels from each image (though "native" includes the entire image). As expected, when the classification is performed on fewer pixels, the performance degrades.

Detecting forged image regions

The algorithm shown in Section 4 can be applied locally to detect regions of an image that have possibly been tampered with. The main work is: demosaicing produces periodic correlations in the image signal. When a image is manipulated, an image piece from another source (it can be from another image or a computer graphic) is pasted over a portion of the image. In general, this image piece is resample to match the geometry of the image.

The application of the highpass filter is the same as previously described. Estimating the variance becomes a local operation.

$$m(x,y) = \frac{1}{2n+1}\sum_{i=-n}^{n} o(x+i,y+i) \qquad (8)$$

Where $o(x,y) = |h(x,y) * i(x,y)|$, the absolute value of the output of applying the filter h(x, y) to the image i(x, y). The parameter n is the size of the local neighborhood; by default we use n = 32. At each position (x, y), a local (256 point) one-dimensional DFT is computed along each row, and the local peak ratio s(x, y) is computed as described before in Eq. (2).

The above equation estimates the variance for detecting forged image regions.

VI. CONCLUSION

Our proposed approach effectively distinguish the Photographic Image and Photorealistic Image with detection of demosaicing in a digital image. Our algorithm validates: distinguishing original Photographic Image from the Photorealistic ones. We state that all of photographic images are compressed JPEG images directly from the digital camera. Therefore they have true demosaicing, nonlinear rendering, and JPEG compression. Morphed image generated from computer graphics systems do not use an image sensor.

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