Available online at www.elixirpublishers.com (Elixir International Journal)

Electrical Engineering

Elixir Elec. Engg. 72 (2014) 25450-25453

ISSN: 2229-712X

Photomorphing detection using demosaicing

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ARTICLE INFO

Article history:

Received: 12 March 2014;

Received in revised form:

19 June 2014;

Accepted: 2 July 2014;

Keywords

Photomorphingdetection,

Demosaicing algorithm,

Forgery detection,

Peak frequency.

ABSTRACT

The field of computer graphics is rapidly maturing to the point where human subjects have difficulty distinguishing photorealistic computer generated images (PRCG) from photographic images (PIM). In legal situations and in the intelligence community where photographs are used as evidence, it is crucial to understand whether the image is authentic or forged. So, it is very essential to develop the system which can distinguish between original images and computer generated images. Computer graphics many softwares are capable of generating highly photorealistic images that can be impossible to differentiate from photographic images. Therefore, classifying photographic images and photorealistic computer graphics has become an important problem for image forgery detection. So, we are providing the novel approach for this problem using Demosaicing algorithm. Demosaicing algorithm is having some special features. Missing color values are determined from a weighted linear combination of neighboring pixels. The process of demosaicing interpolates the raw image to produce at each pixel an estimate for each color channel. With proper analysis, traces of demosaicing are exhibited in the peak of an analysis signal. The presence of demosaicing indicates the image is from a digital camera rather than generated by a computer.

Introduction

Image morphing has been the subject of much attention in previous decades. There are many powerful softwares available in market for Image morphing. This availability brought with it new challenges related to the integrity and authenticity of digital data, specially in images. Photo editing software packages and digital cameras are used to create and modify digital images easily and manipulated without leaving any obvious traces of which have been modified. When digital images used as legal photographic evidence then one can no longer take the authenticity of images for granted. Criminal scene photographs which are presented as evidence in court of law plays an important role in giving final result of a particular legal case. In this context image forensics is concerned with determining the source and potential authenticity of a digital image.

Computer graphics are becoming more photorealistic with increasing technical advances, Therefore, it is important to develop methods for distinguishing between actual photographs from digital cameras and computer generated images. In some situations it is extremely important to distinguish between PRCG and PIM. In legal situations, where photographs are used as evidence, it is crucial to understand whether the image is authentic or forged (either computer generated or altered). Furthermore, in the intelligence community, it is of vital importance to establish the origin of the image. Thus, the imperfections such as dirt, smudges, and nicks that are pervasive in real scenes are difficult to simulate.

Nearly all digital cameras contain an image sensor with a color filter array, for example, the Bayer filter array . A filter is positioned over each photo site, sensitizing it to either the red, green, or blue component of the incident light. Image sensor is a device that converts an optical image into an electronic signal. Whereas, a color filter array is a mosaic of tiny color filters placed over the pixel sensor of an image sensor to capture color information. The raw image from the image sensor contains only a single signal value at each pixel position. This pixel value further corresponds to only a single color component (red, green, or blue in the case of the Bayer filter array). Typically, a demosaicing algorithm also called color filter array interpolation, is applied to the raw image to estimate the pixel value for each color component.

A demosaicing algorithm 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).

An interpolated pixel value is produced with a weighted linear combination of neighboring pixel values. The weights directly affect the variance of the distribution from which the interpolated pixel value is drawn. This pattern of variances can be detected and is the basis for detecting demosaicing.

Related work

There are many possible approaches for genuine source of a digital image. In active watermarking [9],an image is truncated to carry an authentication message by the device which capture the images. After truncated an image, the source of image is verified by extracting message. The disadvantage of this method requires parallel coordination between the insertion and extraction of the watermark. Opposite to the active approach, the difference between PRCG and PIM is determined by statistical methods. As for example, in [6], a set of wavelet charactertics are extracted from the images to form a statistical model of PRCG and PIM, and distribution is performed with standard machine learning techniques. In [7], it is shown that PRCG and PIM images are classify by using geometric and physical features which are effective. In essence, because of the lack of perfection of the state-of-the-art computer graphics both of these approaches are effective. For example, in [7], it is shown that PRCG contain unusually occlusion boundaries and sharp edges.

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A reasonable clearification for this is that the incompleteness such as smudges, dirt and nicks that are common in real scenes are difficult to simulate. In any case, as the field of computer graphics matures with more realistic modeling of scene detail and more realistic lighting models, it seems reasonable to assume that the statistical differences between real scenes and computer generated scenes will diminish.

Digital Image Forgery Detection[13] through data embedding In the Spatial Domain is the system designed for digital image forgery detection. It presents a new method which is based on data embedding in spatial domain and cellular automata which is done by calculating the invaluable statistical information of the digital image such as dominant values like C.V, Variance and Mean, median and so on. The cellular automata rule also generates a robust cipher key which can be used to embed into the image. The original image for forgery detection is required for this algorithm. Real forged and nonforged Digital Image examples have been tested using this method.

Meantime In [4], by applying a Laplacian operator to the image the signature is recovered . The Laplacian is shown to have a higher variance at positions corresponding to pixel locations in the original un interpolated image, and Fourier analysis used to recover this pattern. Similarly, in [8] the EM algorithm along with Fourier analysis are used to recover the correlations between neighboring pixels that are introduced through interpolation. In addition, because a forgery is generally created by re sampling an object and inserting it into a target image, this approach has been shown to be useful for detecting candidate forged image regions and is robust to JPEG compression.

Our approach

To distinguish between photographic images (PIM) and photorealistic computer generated images (PRCG) using demosaicing algorithm. It is extremely important to distinguish between Edited images and original images. In legal situations, where photographs are used as evidence, it is crucial to understand whether the image is authentic or forged (either computer generated or altered). Furthermore, in the intelligence community, it is of vital importance to find out the original image. There are several approaches for authenticating the source of digital image but they have some limitation. so, it is essential to develop the system which can accurately identify the original image.

Proposed system

Only a single signal value at each pixel position contained by the raw image from the image sensor. This pixel value forecoming corresponds to only a single color component (red, green, or blue in the case of the Bayer filter array). Generally, a demosaicing algorithm [2,10], which is also called as color filter array interpolation, is applied to the raw image to calculate the pixel value for each color structure. The interpolation may be linear or adaptive. Interpolation is performed by considering the local pixel values of multiple color channels.

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

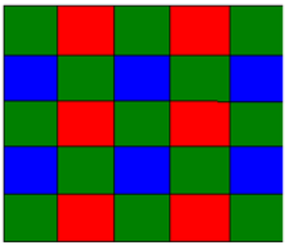

Fig. The Bayer arrangements of color filters on the pixel array of an image sensor. Each two-by-two cell contains two green, one blue, and one red filter.

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.

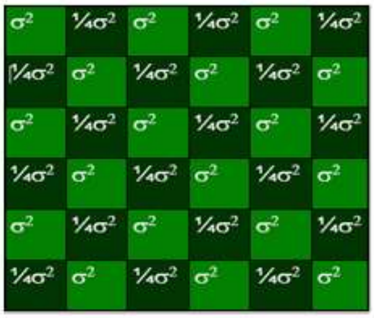

Fig. When demosaicing is performed with linear interpolation, the original green pixels have higher variance than the interpolated green pixels. The spatial pattern of variances is the basis for detecting the presence of demosaicing. The green photosites pixel values in the Bayer array are IID with variance 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 green pixel value can be interpolated from its four nearest neighbors using bilinear

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

Interpolation:

Considering that the original green pixel values are IID and estimated from a normal distribution with variance σ2, the estimated green pixel values can be shown to have a variance of only 1/4 σ2 . As the figure 2 show, the green channel is divided into two interleaved quincunx patterns, one similar to the original green pixel locations, and the other similar to the calculated green 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.

Generally speaking, demosaicing algorithms have several features in common. Missing color values are determined from a weighted linear combination of neighboring pixels, and the sum of the weights is one. An interpolated pixel value is produced with a weighted linear combination of neighboring pixel values. The weights directly affect the variance of the distribution from which the interpolated pixel value is drawn. This pattern of variances can be detected and is the basis for detecting demosaicing. In our implementation, we consider only the green channel of the image to demonstrate our approach. The other color channels (or differences between color channels) can be analyzed in a similar manner. Image processing path contains nonlinear operations such as noise supression, color enhancement, and JPEG compression. This algorithm make no assumptions concerning the linearity of the demosaicing, only that the variance of interpolated pixels is distinguishable from the variance of the original pixels. we demonstrate that despite these nonlinear com- plications, the traces of demosaicing are still detectable and useful for distinguishing PIM from PRCG and for accurately detecting evidence of local tampering.o not balance dimensionally. If you must use mixed units, clearly state the units for each quantity in an equation.

In flow diagram for detecting demosaicing. First a highpass filter is applied, then the variance of each diagonal is estimated.Fourier analysis is used to find periodicities in the variance signal, indicating the presense of demosaicing. Interpolation is performed by considering the local pixel values of multiple color channels.

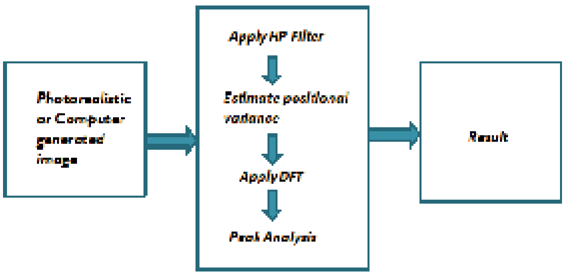

Fig. 1 Flow diagram for detecting demosaicing detecting traces of demosaicing

First, the image i (x, y) is convolved with a highpass operator h(x, y) in order to remove low frequency information and enhance the embedded periodicity when demosaicing has occurred.

We select the operator:

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

Assuming once again that the original green photosites are drawn from a distribution with variance 6ˆ2 ,the variance of the output of the operator h (x, y) on the green channel can be found, if we again make the simplifying assumption that the green channel is interpolated with linear interpolation:

$$\sigma_0^2 = 4\left(\frac{1}{4}\right)^2\sigma^2 + 4\left(\frac{1}{2}\right)^2\sigma^2 + (1-4)^2\sigma^2 = \frac{41}{4}\sigma^2$$

$$\sigma_i^2 = 0\sigma^2$$

σo^2 is the variance of the output of application of h (x, y) at positions corresponding to original green photosites in the image sensor, and thus nine pixel values from the original sensor contribute to the filter output, four with a coefficient ¼ , four with a coefficient ½ , and position (x, y) itself has coefficient -3. σi^2 corresponds to locations where the green value is interpolated (i.e., red or blue photosites), assum-ing the green channel is interpolated with linear interpola-tion. In fact, if missing green 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 green value. The choice of h (x, y) was made to maintain a large value of σo^2 (in our case , assuming)and testing using a small number of training images. A large ratio of 6o^2 aids in the detection of the periodic pattern of variances characteristic of demosaicing.Again, we emphasize that the bilinear interpolation example is merely illustrating the mechanics of how traces of demosaicing are recovered from a photographic image. In practice, the situation is far more complex. Our test im-ages are finished images from real consumer cameras where the demosaicing is actually performed with a nonlinear filter, the color filter array pattern is not known, and the image processing path contains nonlinear operations such as noise supression, color enhancement, and JPEG compression. Our algorithm make no assumptions concerning the linearity of the demosaicing, only that the variance of interpolated pixels is distinguishable from the variance of the original pixels. In the experiments, we demonstrate that despite these nonlinear complications, the traces of demosaicing are still detectable and useful for distinguishing PIM from PRCG and for accurately detecting evidence of local tampering. Next, estimates of the variance of each photosite are made using Maximum Likelihood Estimation. After application of h(x, y), each pixel value is assumed to be drawn from a normal distribution with a particular variance, and the variance along diagonals is assumed to be constant for images that have undergone demosaicing . To compute a MLE estimate of the variance, the statistical variance of the pixel values along each diagonal is found. In keeping with the work of [5], in place of actually computing variance, we use the computationally simpler mean of the absolute values of each diagonal in the image. This projects the image down to a single-dimension signal, m(d), were m(d) represents the estimate of the variance corresponding to the dth diagonal

$$m(d) = \frac{Y = d\ |h(x, y) * i(x, y)|}{Nd}$$

where Nd is the number of pixels along the dth diagonal and is used for normalization.

To find the periodicity in m(d), the DFT is computed to find |M (e^jω)|. A relatively high peak at frequency ω = π indicates that the image has undergone interpolation by a factor of two and is characteristic of demosaicing. The peak magnitude at ω = π is quantified as follows:

$$S = \frac{|M(e^{j\omega})|_{\omega=\pi}}{K}$$

where k is the median value of the spectrum, excluding the DC value. Normalizing by k was found to be important to distinguish between true demosaicing and images containing signals or noise with large energy across the frequency spectrum.

Conclusion

We proposed new approach for determining photographic image and photorealistic computer generated images classification in the context of image forgery detection. We have used the demosaicing algorithm.We found that most cameraas image sensors contain a color filter array and demosacing must be use to produce three color images.When traces of demosaicing are detected, we came to know that the image is the photographic image rather than computer generated image.

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