Towards an Image Blurring Detection Approach based on Color Filter Array

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Abstract—Digital image tamper detection technology is a hot topic in recent decades which has widely applications in image processing. Study of key approach of digital image temper detection has important science and application value. A CFA interpolation based image blur tamper detection algorithm is proposed in this paper. First we reconstruct the tamper image by CFA interpolation artifacts. Then we filter the reconstructed image by Wiener filter and calculate the related degree between the tampering image and the image to be detected. Finally we classify the degree of correlation feature and locate the tampered area. Experimental result shows that the algorithm can effectively detect and locate tampering area of the image been operated by blur tampering and it has a good robustness. The algorithm can accurately locate the image of tampering falsification area and the detection accuracy is significantly better than existing algorithms and can be well positioned image tampering area.

Keywords- blur tamper detection; reconstructed; Wiener filter; the degree of correlation.

I. INTRODUCTION

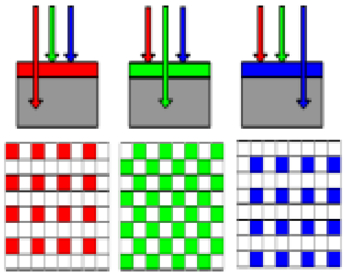
In order to save costs, most digital cameras are produced by a single sensor to get full true color photos using the color filter array (CFA) and some interpolation algorithm. Image interpolation algorithms make pixels have some specific correlation and images have been tampered will most likely destroy or alter the correlation between those features are exploited to detect and locate the tampered image tampering.

A large number of algorithms on digital image forensics technology have been proposed in recent years. Bianchi exploited the JPEG image compression process and estimated the quantization step parameter model estimation methods [1]. Finally they used tamper area and not tampered area quantization table inconsistent locate tampered area. Peng et al [2] proved theoretically double JPEG image compression relationship between the first compression quantization tables and the second quantization tables. Then they used block artifacts locate tampered area and achieved a good results. Wei [3] used a simple way to detect the image re-sampling rate and the image rotation angle, if the image after JPEG compression, image resampling detection rate and the accuracy of the rotation angle of the image will be reduced. Chen et al used the statistical properties of the image after median filtering to detect whether the image is changed after tampering [4]. Wang Wei et al detected traces of fuzzy retouch images by treating the secondary side obfuscate and blur the image using the correlation achieved [5]. Fan et al used the image header file parameter tampering by the degree of change after the operation to detect whether the image is tampered after image forgery operation [6]. Kee et al used a simple way to extract tampering features inconsistency whether the image after tampering [7]. Wang et al. proposed a method for local histogram smoothing method based on the detection of the least significant bit of the image steganography has some effect, but the rate of detection accuracy is not very high [8]. Peng proposed a distribution and other inconsistencies to detect tampering image blur operation using the pixel direction [9, 10]. Different from above work, this paper proposed a detection method based on fuzzy CFA interpolation reconstruction.

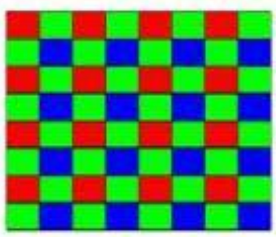
Contrary to the above-mentioned disadvantages, this paper proposed a blurred trace detection method based on CFA interpolation reconstruction. We use the CFA interpolation detected image and its reconstructed Wiener filtering, reconstruct image and calculate the filtered image to be related to the degree of alteration, extract and classify the relevant features of the altered region of the positioning. The algorithm has very good effective for different types of fuzzy tampering.

II. MONOCHROME SENSOR DIGITAL CAMERA IMAGING PRINCIPLE

Only one third digital pixel values are captured from the real scene. The remaining two thirds of the pixel values are estimated by interpolation algorithms combine color filter array are shown in Fig .1, the sensor can only collect accurate information for a single color channel and the pixel values of the rest of the missing data are combined with the color filter array interpolation algorithms estimated. The most common color filter array is the Bayer pattern.



(a) Monochromatic device



(b) Bayer pattern

Figure 1. Bayer model

The imaging process of monochrome sensor digital camera is as follows: First, the natural light entered digital camera through lens. Then the light is captured by monochrome sensor through various filters. However, monochrome sensor can only obtain the information from the intensity of color channels light. To obtain true color information, the light should pass through the color filter array first. The function of filter is passing the light with certain length, so as to achieve the required intake the purpose of the color. CFA is specified for each pixel on the sensor sampled in one of three primary colors, the pixel values of these interpolated samples, the formation of each individual color bit planes. There are many color interpolation algorithms based on smooth chroma interpolation algorithm, based on edge-aware interpolation algorithm and based on the weighted gradient directional interpolation algorithm. Different digital products use different interpolation technologies. After color interpolation and gamma correction, the image is written into camera memory with user-defined image formats (such as BMP, TIFF, JPEG, et. al.). The entire imaging process is completed.

III. THE IMAGE CFA INTERPOLATION PROCESS

Reconstruction for the Bayer matrix interpolation obtains all the values of R, G, B channel. S(x, y) represents a Bayer matrix, R'(x, y), G'(x, y), B'(x, y) represents the original pixel value from the Bayer matrix which can be directly obtained R, G, B three-channel.

$$R^{'}(x,y)=\begin{cases} S(x,y), & S(x,y)=r_{x,y} \\ 0, & otherwise \end{cases} \quad (1)$$

$$G^{'}(x,y)=\begin{cases} S(x,y), & S(x,y)=g_{x,y} \\ 0, & otherwise \end{cases} \quad (2)$$

$$B^{'}(x,y)=\begin{cases} S(x,y), & S(x,y)=b_{x,y} \\ 0, & otherwise \end{cases} \quad (3)$$

Reconstruction a full color image requires the use of the non-zero value interpolation of R'(x, y), G'(x, y), B'(x, y) to reconstruct from the complete three color channels r(x, y), g(x, y), b(x, y).

$$r(x,y)=\sum_{u,v=-N}^{N} h_r(u,v)R^{'}(x-u,y-v) \quad (4)$$

$$g(x,y)=\sum_{u,v=-N}^{N} h_g(u,v)G^{'}(x-u,y-v) \quad (5)$$

$$b(x,y)=\sum_{u,v=-N}^{N} h_b(u,v)B^{'}(x-u,y-v) \quad (6)$$

Where, hr(·), hg(·), hb(·) represents the interpolation kernel for each color channel, the size is (2N+1)2. Different interpolation algorithms which interpolation different kernel functions, the use of a linear interpolation algorithm, the interpolation kernel function for green channel is hg, interpolation kernel function for the red channel is hr, blue channel interpolation kernel function is hb.

$$h_r=\frac{1}{4}\begin{bmatrix}1&2&1\\2&4&2\\1&2&1\end{bmatrix} h_g=\frac{1}{4}\begin{bmatrix}0&1&0\\1&4&1\\0&1&0\end{bmatrix} h_b=\frac{1}{4}\begin{bmatrix}1&2&1\\2&4&2\\1&2&1\end{bmatrix}$$

$$r(3,3)=r_{3,3}\ ,\quad g(3,3)=\frac{g_{2,3}+g_{3,2}+g_{3,4}+g_{4,3}}{4}\ ,$$

$$b(3,3)=\frac{b_{2,2}+b_{2,4}+b_{4,2}+b_{4,4}}{4}$$

$$r(3,4)=\frac{r_{3,3}+r_{3,5}}{2}\ ,\quad g(3,4)=g_{3,4}\ ,\quad b(3,4)=\frac{b_{2,4}+b_{4,4}}{2}$$

$$r(4,4)=\frac{r_{3,3}+r_{3,5}+r_{5,3}+r_{5,5}}{4}\ ,$$

$$g(4,4)=\frac{g_{3,4}+g_{4,3}+g_{4,5}+g_{5,4}}{4}\ ,\quad b(4,4)=b_{4,4}$$

$r_{1,1}$	$g_{1,2}$	$r_{1,3}$	$g_{1,4}$	$r_{1,5}$	$g_{1,6}$	
$g_{2,1}$	$b_{2,2}$	$g_{2,3}$	$b_{2,4}$	$g_{2,5}$	$b_{2,6}$	
$r_{3,1}$	$g_{3,2}$	$r_{3,3}$	$g_{3,4}$	$r_{3,5}$	$g_{3,6}$	
$g_{4,1}$	$b_{4,2}$	$g_{4,3}$	$b_{4,4}$	$g_{4,5}$	$b_{4,6}$	$\cdots$
$r_{5,1}$	$g_{5,2}$	$r_{5,3}$	$g_{5,4}$	$r_{5,5}$	$g_{5,6}$	
$g_{6,1}$	$b_{6,2}$	$g_{6,3}$	$b_{6,4}$	$g_{6,5}$	$b_{6,6}$	
			$\vdots$			$\ddots$

Figure 2. Bayer matrix example

Fig .2 is a Bayer matrix (3,3), (3,4) and (4,4) pixels. Then the pixels of the interpolated correction shown in Fig .2 (3,2) position of the interpolated r (3,2), and the original g (3,2) respectively, the discrete wavelet transform, taking r (3,2) discrete wavelet transform low-frequency region and the high frequency region g (3,2) discrete wavelet transform wavelet inverse transform, thus corrected picture.

Shown in Fig .3, using the above algorithm in Fig .3 (a) are reconstructed to obtain Fig .3 (b), the algorithm can reproduce the original image, but not difficult to find at the edge of image detail, there will be vibration bell effect. And most of the existing image reconstruction algorithm is designed to improve the performance of the algorithm to reduce the ringing effect.

(a) original image

(b) reconstructed image

Figure 3. CFA Interpolation Reconstruction

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$$u_1 = \frac{1}{M \times N}\sum_{i=1}^{M\times N} x_i \tag{7}$$

$$u_2 = \frac{1}{M \times N}\sum_{i=1}^{M\times N} y_i \tag{8}$$

$$\sigma_x = \sqrt{\frac{1}{M \times N - 1}\sum_{i=1}^{M\times N}(x_i - u_1)^2} \tag{9}$$

$$\sigma_y = \sqrt{\frac{1}{M \times N - 1}\sum_{i=1}^{M\times N}(y_i - u_2)^2} \tag{10}$$

$$\sigma_{xy} = \frac{1}{M \times N - 1}\sum_{i=1}^{M\times N}(x_i - u_1)(y_i - u_2) \tag{11}$$

$$T = \frac{\sigma_{xy}}{\sigma_x \sigma_y} \tag{12}$$

After getting the matrix T, we can categorize it into M1 and M2. M1 is the degree difference of T matrix which has not been tampered. M2 is degree difference of T matrix which has been tampered. Using EM method [1] to get its expectation and variance is as follows:

$$P\{L(k,l) \mid M_1\} = N(u_3, \sigma_1) \tag{13}$$

$$P\{L(k,l) \mid M_2\} = N(u_4, \sigma_2) \tag{14}$$

The feature matrix AL is as follows:

$$AL = \frac{(L-u_3)^2}{2\sigma_1^{\ 2}} - \frac{(L-u_4)^2}{2\sigma_2^{\ 2}} \tag{15}$$

Then matrix AL is filtered by the 3×3 median filter. The filtered result is processed with banalization, thereby obtaining the fuzzy tampered area.

IV. Experimental Results and Analysis

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The pattern is shown in Table 1:

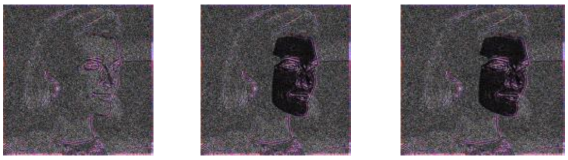
TABLE I. Different Fuzzy Model and Related Parameters

Fuzzy pattern	Blur radius or distance
Gaussian blur	1
Lens blur	5
Shape fuzzy	5
Motion blur	5

Fig .3 (a) of the test image by fuzzy pattern different from the above four fuzzy treating the resulting image in Fig .3 retouch tampering (b) ~ (e) below. The application referred to herein have tampered image detection algorithm based on fuzzy trace CFA interpolation reconstruction testing, test results of the experiment in Fig .3 (g) ~ (k) below. As can be seen from the detection result of the experiment, the grey zone and the pixel values after post-reconstruction image to be detected closer to the smaller effective reconstructed ringing generated, and in the detection result is a black area shows the study herein detection method has better detection results. The experimental results with the literature [5] contrast.

(a) Original (b) Gaussian blur (c) lens blur

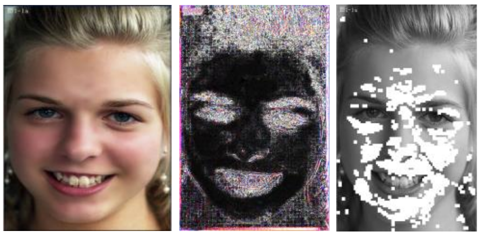
(d) the shape of fuzzy (e) Motion Blur (f) Gaussian blur



(g) Original test results (h) Gaussian Blur test results (i) lens blur test results

(j) the shape of fuzzy test results (k) Motion Blur test results (l) [5] test results

Figure 4. different types of test samples and fuzzy test results



(a) tampering with the image (b) proposed algorithm test results (c) [5] test results

Figure 5. blurred image tamper detection results

Results Fig .4 and Fig .5 can be found in the literature [5] The algorithm can more accurately detect the tampered image tampering forgery area, but the result of detection, there are some false alarm region and the area of undetected. The proposed algorithm can accurately locate the image of tampering forged region, and the detection accuracy significantly better [5] is well positioned in the area of image tampering in the literature and the proposed algorithm. At the same time for different types of operations is fuzzy tampering with good results.

V. CONCLUSION

This paper discussed an image CFA interpolation algorithm based on fuzzy tamper detection. Firstly, the detected image is reconstructed using CFA interpolation effects. And then the detected image filtered by Wiener filter. Thirdly, we calculate its association degree between filtered reconstructed image and the original image. Finally, the feature of association degree is classified and tampered area will be located. Experimental results show that the algorithm for different types of fuzzy tampering and has a good effects.

ACKNOWLEDGMENT

This work was supported by a grant from the Hubei Provincial Department of Education scientific research programs for youth project (No. Q20133003) and the natural science foundation of Hubei Province (No. 2014CFB568).

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