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Detecting Image Forgery using XOR and Determinant of Pixels for Image Forensics

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***Abstract*—Using images in case investigation may doubt that the image are forged or not. Image forensics is an approach for image validity. In this paper, we propose a new method for detecting forgery of image that use of the truth from XOR comparison between two images; and the determinant of 3x3 pixels for more performance instead of comparing pixel by pixel. Euclidean of a pixel is computed to reduce the dimensions from RGB vectors. In this experiment, XOR with pixel-by-pixel and XOR with determinant of 3x3 pixels were compared. Fifty images were used: 25 real images and 25 forged images. The result showed that our new method increased speed 36.42% and the error was at 13%.**

Keywords- Determinant; Image Forensics; Image Forgery

I. INTRODUCTION

Nowadays, image technology is rapidly growth. Many software are convenient for editing or tampering images. Forged images are used in many events such as discredit, over-advertisement, hiding the fact, misunderstanding etc. These events affect reputation of the victim. In forensics science, images are necessary for using as evidence in investigation: physical evidence and suspects [1]. Images are collected for using in the case investigation. Using images in case investigation may doubt that the image are forged or not [2]. Image forgery becomes hazard through the internet which may become litigation [3].

There are many researches about detecting image forgery. Jan Lukas and et al [4] proposed the method using pattern of noise. The pattern of noise depended on calibration value of camera. If the pattern of noise in some regions were too less, that region might be forged. Alin C Popescu and et al [5] segmented the image into fix-sized blocks to compare noise and compression between two images using PCA. Jessica Fridrich and et al [6] and Yanjun Cao and et al [7] used the DCT coefficient of robust match for estimating the region of image where has been copied or moved. This method took very long time. Preeti Yadav and et al [8] used DWT for grouping the compressed values. However, image forgery detection has a limitation in time processing. Because most method uses pixel by pixel to compare.

This paper proposes the method for detection of image forgery from XOR between two images and determinant of pixels; which can reduce the time. In this experiment, XOR with pixel-by-pixel and XOR with determinant of 3x3 pixels were compared. Fifty images were used: 25 real images and 25 forged images. The result showed that our new method increased speed 36.42% and the error was at 13%.

II. PRELIMINARY

The determinant of matrix is described in section 2.1, first-order neighborhood system in section 2.2, and XOR in section 2.3

A. Determinant of Matrix

Determinant is a method that computes to find the representative of members in squared matrix. In geometry, determinant is a scale factor of a volume. Determinant is useful for substitution rule in linear algebra and calculus [9].

An example of determinant of matrix A

$$\text{Define } A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

Determinant of A can be computed from (1);

$$\det A = |A| = ad - cb \tag{1}$$

For example, $A = \begin{bmatrix} 3 & 8 \\ 4 & 6 \end{bmatrix}$; $\det A$ can compute as:

$$\det A = |A| = (3 \times 6) - (8 \times 4) = 18 - 32 = 14$$

Paatero and Tapper [10] used determinant of matrix and projected gradients for organizing the most similar pixels into the same group. The dimensionality and

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complexity of computation can be reduced. The advantage of determinant are summarizing many values into a single value, determining the result from the model, and validating the model.

B. *First-order Neighborhood System*

First-order neighbors of a pixel have 8-pixels that locate around the pixel as shown in Fig.1. Yang and et al [13] used the first-order neighbors, second-order neighbors and third-order neighbors for edge detection, where 0 is edge, -1/1 is first-order neighbors of edge, -2/2 is second-order neighbors of edge, and -3/3 is third-order neighbors. The prior minus sign means the pixel is not in the region and no sign means the pixel is in Figure 1.

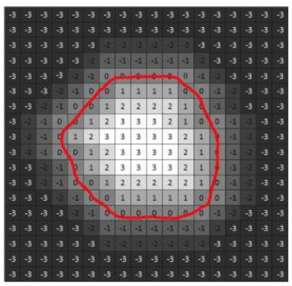


Figure 1. Neighborhood for Edge Detection [13]

C. *XOR*

XOR/Exclusive-OR is a logic operator where the output is 1 if input are different value. And the output is 0 if input are the same value. The notation of XOR is

Wu and Sun [17] used XOR for encryption and decryption and the XOR could make the system become more secure.

III. Proposed Method

This paper used the truth from XOR comparison between two images; and the determinant of 3x3 pixels for detection of image forgery: (1.) Find the pixel and its neighbors, (2.) Compute the euclidean of RGB, (3.) Compute determinant of pixels, and (4.) Compare determinant of pixels between two images

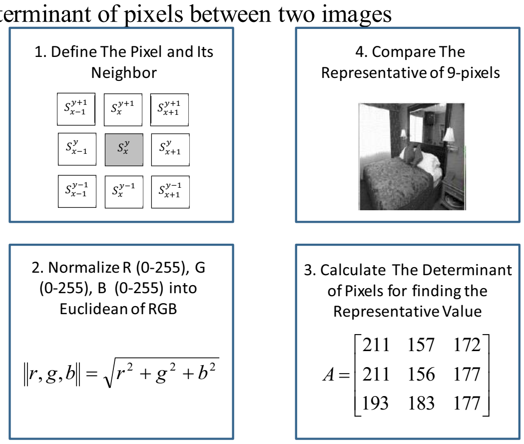


Figure 2. Framework of our Proposed Method

A. *Computation of First-order Neighbors*

Compute the representative value of 9 pixels using first-order neighbors of a pixel as shown in Fig. by (2).

$$N^{\varpi=1}(s) = \left\{S_{x-1}^{y-1}, S_{x}^{y-1}, S_{x+1}^{y-1}, S_{x-1}^{y}, S_{x+1}^{y}, S_{x-1}^{y+1}, S_{x}^{y+1}, S_{x+1}^{y+1}\right\} \quad (2)$$

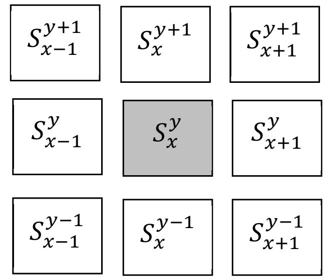


Figure 3. First-order Neighborhhod System

B. *Euclidean Computation*

A pixel has many variables. Euclidean is used to decrease dimensionality of variables. Each pixel consists of the red value, green value and blue value. Euclidean is used as a normalized representative value for RGB of a pixel using (3).

$$\|r,g,b\| = \sqrt{r^2+g^2+b^2} \quad (3)$$

C. *Determinant Computation*

Compute the determinant of 9 pixels to find the representative of the pixel values;

$$\text{Define } A = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}$$

Determinant can calculate from (4);

$$\det A = (aei + bfg + cdf + cdh) - (gec + hfa + idb) \quad (4)$$

Example of Determinant of 3x3 matrix

$$\text{Define } A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

$\det A$ can calculate as,

$$\det A = |A| = (1\times5\times9) + (2\times6\times7) + (3\times4\times8) - (7\times5\times3) - (8\times6\times1) - (9\times4\times2)$$

D. XOR Comparison between two images

XOR is used to compare the determinant of pixels between forged image and real image.

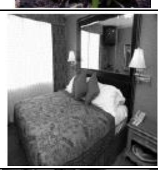
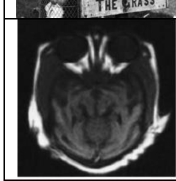
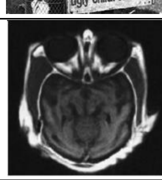
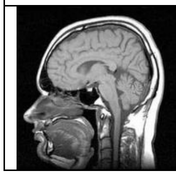
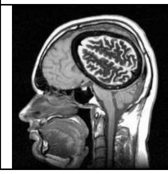
TABLE I. TRUTH TABLE OF XOR

A	B	$A \oplus B$
0	0	0
0	1	1
1	0	1
1	1	0

IV. EXPEROMENTAL RESULT

This experiment used 50 images: 25 real images and 25 forgery of real images. XOR of pixel by pixel and XOR of determinant of pixels between two images are compared as shown in Table II.

TABLE II. RESULTS BETWEEEN PIXEL-BY-PIXEL AND DETERMIANANT OF 9-PIXELS

Original image	Forgery image	Time (Second)	
		Pixel-by-pixel	Proposed method
		51	42
		41	25
		71	59
		66	32
		62	41
		40	22
		49	32

This experiment evaluated in term of time and error rate. From table III, the results missed from XOR pixel-by-pixel around 13%. The error rate was measured by precision equation in (5).

$$precision = \frac{tp}{tp + fp} \tag{5}$$

where tp= True Positive, fp= False Positive

Determinant of 9 pixels was computed in one iteration. The pixel-by-pixel had higher accuracy. But in case of the same object such as region of a bed, the determinant of 9 pixels had high accuracy almost the pixel-by-pixel.

V. CONCLUSION

Our method enhanced from XOR with pixel-by-pixel. Determinant of pixels is computed to find the representative of the group. The speed improved to 36.42%. And the error rate is around 13%. This method can integrate with trigonometry for solving the geometric correction such as rotated images. Detecting the forgery can use the real image for comparison from the internet.

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