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Tamper Detection with Reduced Time Complexity Using Hybrid Techniques

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Abstract— ***Availability of powerful image processing and editing software is an advantage for manipulating digital images. Detection of malicious manipulation of digital images (digital forgeries) by augmenting the techniques like DWT-PCA, DWT-phase correlation and complimenting each other's weakness for effective/enhanced detection of tampered region from images which are subjected to various geometrical constraints is the main objective of this paper. In particular, the focus is on detection of a special type of digital forgery – the copy-move attack. The method discussed in this paper successfully detects the forged part even when the copied area is enhanced/ retouched and is saved in a lossy format, such as JPEG. The performance of the proposed method is demonstrated on several forged images and is proven.***

Index Terms— **Copy-Move Forgery Image, JPEG, Reduced Time Complexity, DWT, PCA, Phase Correlation.**

I. INTRODUCTION

Copy move forgery is one of the digital forgeries which is copying a part of the image and pasting into another part of the same image, with the intention to hide an object or a region of the image. An image containing this type of forgery can be detected using duplicated regions. Duplicated regions may not always match exactly. For example, this could be caused by a lossy compression algorithm, such as JPEG, or by possible use of the retouch tool. Existing copy–move forgery detection methods are mostly based on matching of overlapping image blocks. For example, Fridrich et al. [1] has proposed a method which is based on matching the quantized lexicographically sorted discrete cosine transform (DCT) coefficients of overlapping image blocks. The lexicographically sorting of DCT coefficients is carried out mainly to reduce the computational complexity of the matching step. Another method proposed by Popescu and Farid [2] and it is similar to [1]. The main difference of this method from [1] is mainly the representation of overlapping image blocks. In this paper the principal component transform (PCT) has been employed in place of DCT. The representation of blocks by this method has better discriminating features. As pointed out in [1], ideal regions for using copy—move forgery are textured areas with irregular patterns, such as grass. Because the copied areas are likely to be blended with the background it would be very difficult for the human eye to detect widths, line spacing, and any suspicious artifacts. Another fact that complicates the detection of this type of tampering is that the copied regions may be from the same image. They therefore have similar properties, such as the noise component or color palette. This makes the use of statistical measures to find irregularities in different parts of the image impossible.
The rest of this paper is organized as follows, In Section II, section A is about DWT section B.1) DWT-PCA algorithm B.2) Methodology. In Section III section A is about DWT-Phase correlation technique, section B is about the Methodology. Section IV, the comparison results of both the techniques. Section V concludes the paper with future enhancement.

II. PRINCIPAL COMPONENT ANALYSIS

A) Discrete Wavelet Transform:

Discrete Wavelet Transform employs Multi-resolution technique for dimensional reduction. Multiresolution means analyzing different frequencies with different resolutions. At each level, the image is decomposed into four sub images LL, LH, HL and HH. This image is used for further decomposition. LH HL and HH correspond to the vertical, horizontal and diagonal components of the image respectively. These sub images can be combined to restore the image which is decomposed. In this paper two level discrete wavelet transform is employed and out of the different types of wavelet family Daubechies 4 is used for image reduction and analysis.

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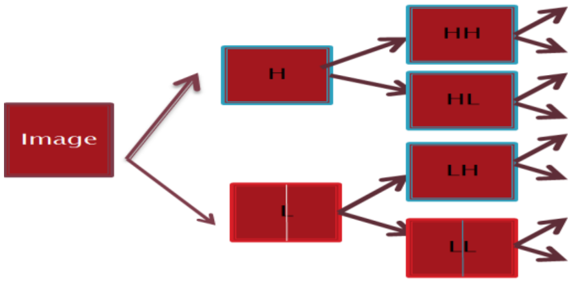


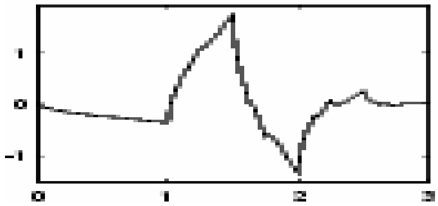
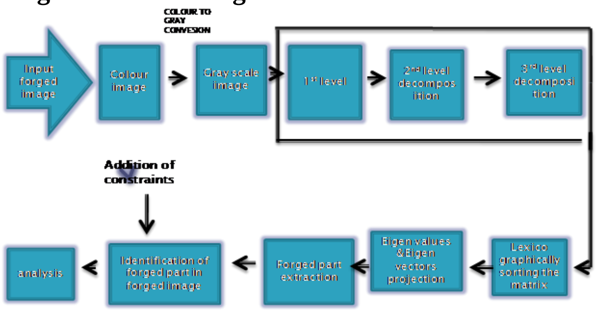


Fig 1- Daubechies 4

In DWT, the most prominent information in the signal appears in high amplitudes and the less prominent information appears in very low amplitudes. So this transform is utilized for dimension reduction. High data compression can be achieved by discarding low amplitudes frequency values of the image. In addition to high compression ratios good quality of reconstruction is achieved through this type Discrete Wavelet Transforms.

Forged region detection through DWT-PCA Algorithm:



B.1) DWT-PCA Algorithm:

Step 1: Color forged image is converted to gray image.
Step 2: Gray image is subjected to dimensional reduction by discrete wavelet transform.
Step 3: With the high frequency sorted image matrix ,obtain the eigen vectors and values.
Step 4: Projections of the centered testing gram matrix on the ordered eigenvectors is performed.
Step 5: Lexicographically sort the projected version of the centered testing gram matrix [S].
Step 6: For every ith rows i in S, select a number of subsequent rows, sj such that |i-j|<=Rth and place all the pairs of coordinates (xi,yi) and (xj,yj) on to a list P_in.
Step7: Compute offset for each row of P_in.
Step 8: Compute the frequency offset.
Step 9: Those rows in P_in which have high frequency offsets are the duplicated regions

B.2) Methodology of applying DWT-PCA:

The Coloured input forged image has high dimensionality so converted as M×N dimentional gray scale image.To further reduce the dimension it is subjected to DWT.The high frequency image matrix A is considered for further processing.The eigenvalue problem is to determine the nontrivial solutions of the equation

$$Ax = \lambda x \qquad (1)$$

where A is high frequency matrix, x is a length of n column vector, and λ is a scalar. The n values of λ that satisfy the equation are the eigenvalues, and the corresponding values of x are the right eigenvectors. The largest eigenvalues are called dominant eigenvalues and their corresponding eigenvectors are called dominant eigenvectors.

For eigenvector $[c,d]^{T}$P, the direction U of the dominant eigenvector is defined by

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$U = \tan^{-1}(c/d)$ where $0^o <= U <= 90^o$ (2)

Gram matrix are then projected on to the ordered eigen vectors. The grammians is used to determine the controllability and observability of state-space models and for model reduction.

The controllability grammian is defined by

$$W_c = \int_0^{\infty} e^{A\tau} BB^T e^{A^T\tau} d\tau \quad (3)$$

and the observability grammian by

$$W_o = \int_0^{\infty} e^{A^T\tau} CC^T e^{A\tau} d\tau \quad (4)$$

The discrete-time counterparts are

$$W_c = \Sigma^{\infty} A^k BB^T [A^T]^k \quad (5)$$

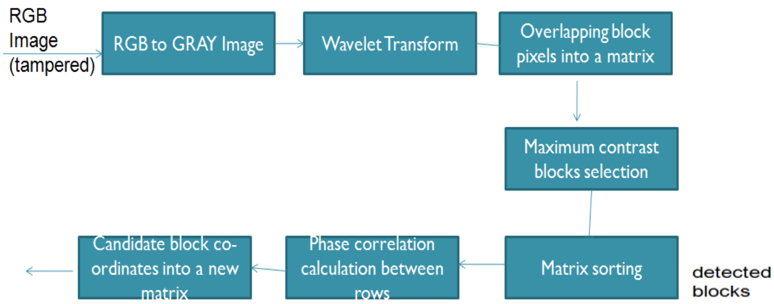
$$W_0 = \Sigma^{\infty} [A^T]^k CC^T A^k \quad (6)$$

Centered tested gram matrix obtained from (1), (2), (3), (4) & (5) are sorted lexicographically. Pairs of coordinates are listed as a matrix. Offset are found which removes or keeps values from the beginning or end of a vector and outputs the result in a vector of user-specified length such a high frequency offsets gives the duplicated region.

III . PHASE CORRELATION

A. Forged region detection through DWT- Phase Correlation Algorithm:

In this second method of forgery part detection, three levels of decomposition are performed. Overlapping block pixels are calculated. Blocks that have maximum contrast are sorted separately. Phase Correlation done between remaining blocks. Similarly the images at each level of decomposition are subjected to phase correlation. This on repetition and comparison yields the duplicated region [4]



To find the phase correlation the following formula is used. The ratio R between two images img1original image and forged image img2 is calculated as follows.

R = F (img1) ×conj (F (img2)) / ||F (img1) ×conj F (img2)) ||

Where F is the Fourier Transform and conj is the complex conjugate. The inverse Fourier Transform of R is the phase correlation. [4]

B. Basics of Phase Correlation

Phase correlation provides straight-forward estimation of rigid and relative translational motion between two images which is based on the well-known Fourier shift property: a shift in the spatial domain of two images results in a linear phase difference in the frequency domain of the Fourier transforms (FT). Let the functions $g(x,y)$ and $h(x,y)$ representing two images related by a simple translational shift a in horizontal and b in vertical directions, and the corresponding Fourier transforms are denoted as $G(u,v)$ and $H(u,v)$. Thus,

$$H(u,v) = G(u,v) \exp\{-i(au + bv)\} \text{------------------------------} \quad (1)$$

The phase correlation is defined as the normalized cross power spectrum between G and H, which is a matrix:

If $G(u,v)$ and $H(u,v)$ are continuous functions, then the inversed Fourier Transform (IFT) of $Q(u,v)$ is a delta function. The function peak identifies the integer magnitude of the shift between the pair of images [Kuglin, and Hines, 1975]. To achieve the translation estimation at sub-pixel accuracy based on the delta function of the IFT of phase correlation matrix $Q(u,v)$, over sampling the images $g(x,y)$ and $h(x,y)$ to sub-pixel level before the applying Fourier transform of phase correlation operations. This increases the computing load dramatically. As the magnitude of $Q(u,v)$ is normalized to 1, the only variable is the phase difference defined by $au+bv$, where a and b are the horizontal and vertical magnitudes of the image shift between $g(x,y)$ and $h(x,y)$.

If a and b *are solved* accurately based on the phase correlation matrix $Q(u,v)$, then the non-integer translation estimation at sub-pixel accuracy can be achieved without applying IFT. Such direct frequency domain approaches

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is more accurate and faster than that of the delta function method. The phase difference angle $c = au+bv$ is a planar surface through the origin in *u*-*v* coordinates defined by coefficients *a* and *b*. Thus a complicated problem of complex numbers in frequency domain becomes a simple issue of finding the best 2D fitting of the phase difference angle data in $Q(u,v)$ to a plane of phase difference in the coordinates of *u* and *v*. The phase shift angle *c* is 2π wrapped in the direction defined by *a* and *b* [Foroosh *et al.*, 2002; Hoge, 2003].

IV. EXPERIMENTAL RESULTS

A) DWT- PCA ALGORITHM:

[MULTIPLE FORGERY PART DETECTION]

Fig1: Forged Color Image1

Fig2: Original color Image2

Fig 3: Gray Image1

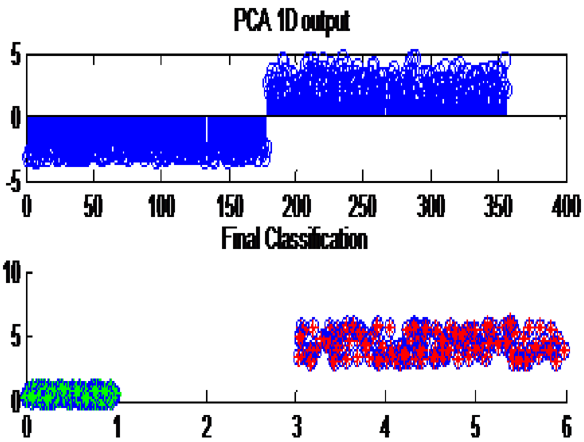

Fig4 : Final Classification Using Pca

Fig5: After Projecting The Frequency Offset Onto Image/Forgery Part

Fig6: Single Forgery Part Being Detected:

Fig7: PCA Working On 90 Degree Rotated Image

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B) DWT-Phase correlation:

Fig1: Forged Image

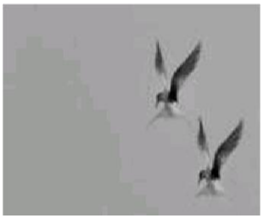

Fig2: Forged Part Detected

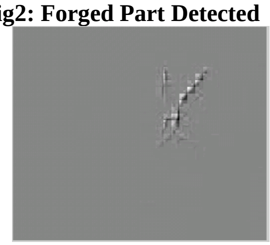

Table 1: COMPARISON OF BOTH RESULTS

BASIC CONSTRAINTS	OPERATION	METHODS FOR COPY-MOVE FORGERY DETECION		EFFICIENCY
		DWT + PHASE CORRELATION	PCA METHOD	
GEOMETRICAL TRANSFORMS	ROTATION AT 180 &90 DEGREE	ROBUST	ROBUST	BOTH METHODS SIMILAR
	ROTATION AT 45 DEGREE, SHIFTING, SCALING	FAILS	FAILS	SIMILAR TO BOTH METHODS
NOISES	SALT AND PEPPER NOISE	ROBUST	ROBUST	SIMILAR TO BOTH METHODS
	GAUSSIAN , POISSON, SPECKLE NOISE	ROBUST	FAILS	DWT, PHASE CORELLATION (GOOD)

V. CONCLUSION

In this paper two algorithms are proposed for detecting copy move forgery. The techniques proposed in the paper like DWT-PCA, DWT-phase correlation are compared and are complimented with each other's weakness for effective/enhanced detection of tampered region from images that are subjected to various geometrical constraints. From the considered samples it is proved in this paper that DWT-PCA produces a better result over DWT-phase correlation. However the algorithm produces less efficient output over other samples. And in future this algorithm can be tested by changing different background images and also can be extended to withstand JPEG compressions.

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