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# A Passive Technique based on CWT FFT for Region Duplication Detection in Digital Images

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**Abstract: Copy move forgery is the widespread type of image forgery witnessed in the contemporary world .In such cases a segment of an an image copied there-after pasted on at another position of same image. Here in this paper, we used Complex Wavelet features to find the Image Duplicates. The approximation band is divided into 6 sub bands and eventually Fourier Transform is applied on each part. Phase correlation is used to find the duplicate regions. This technique is compared with state of the art techniques by experimenting various parameters like Detection Accuracy (DA), False Positive Rate (FPR) , False Negative Rate (FNR). The analysis proved that CWT-FFT technique is able to detect copy-move forgery attack with high Detection Accuracy than other existing methods.**

***Keywords —Complex Wavelet Transform, Copy-move Forgery, Digital Image Forensics, Fast Fourier Transform, Region Duplication.***

## I. INTRODUCTION

The methods for detection of forgeries in digital images are mainly divided into two categories named as Active and Passive methods. Digital watermarking [1] is an example of the Active Detection method. In this process signature, date and name are basically used for forgery detection. The several active methods require software and hardware equipment for comparing forged and original image information. Hence, Active methodologies are costly. Using Passive Detection methods, it is possible to detect the forgery in images without using original image watermarks or signatures. So the Passive methods are also referred to as Blind Techniques. They don't require any of a priori information. Such techniques are used when forged image leaves no visual hint for identifying alteration although some significant changes are made to the image. These passive methods are based on post-processing of digital image data. To identify the copy-move attack is more challenging when some geometrical attack (rotation, rescale) or (and) post-processing operations (additive Gaussian noise, blur, adjustment of brightness) are used by attacker on copy-move region, so that the forged image looks like natural one.

## II. PROPOSED WAVELET TRANSFORM AND FFT BASED METHOD FOR REGION DUPLICATION DETECTION

Traditionally, Wavelet Transform based region duplication detection method was used, in order to extract features from image blocks. Initially, authors used Wavelet Transformations i.e. Dyadic Wavelet Transform (DyWT), Discrete Wavelet Transform (DWT) etc. and decomposed input or test image into sub bands, viz., approximation, horizontal, vertical and diagonal sub-bands. Approximation sub band plays the major role in the detection of duplicate image regions because of low entropy. The energy coefficients of approximation sub-bands are the features of the image. In the proposed work, we use Complex Wavelet Transformation. The proposed method is explained in detail in the below Section.

Here, in this method, we applied CWT on a possibly forged image and obtained the six sub bands of it. After dividing the Approximation sub bands into nine equal non overlapping sub images, Fast Fourier Transform (FFT) [36] is applied on each sub image and the normalized cross power spectrum [37] of every pair of sub images is computed. Next, Inverse FFT is applied to the normalized cross power spectrum and its peak value is obtained using Phase Correlation method [38]. Extraction of the peak helps in calculation of the offset between the copy-move regions in the forged image. Thereafter, the forged image is shifted

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by the calculated off set and the shifted version is overlaid on the original one.

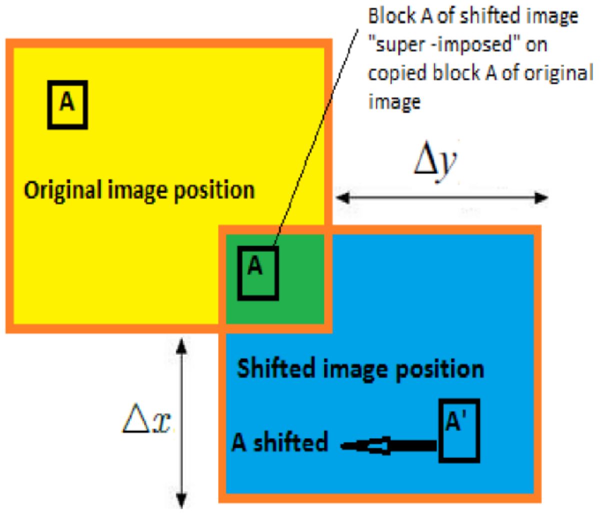


Fig. 1. Pixel Matching by Image Shifting.

The difference between the new image obtained after the overlap operation, and the original image, is calculated. If the difference is less than a user defined threshold, then we can infer that the corresponding pair of sub images, contains the duplicated regions.

In detail, the basic steps of the proposed methodology are given as follows:

1. Complex Wavelet Transform is applied on the possibly forged image. Let its approximation sub band be represented by LL1.

2. LL1 is further divided into nine equal non overlapping fixed size sub images I1, I2, ......... I9.

3. FFT is applied on each sub image and the normalized cross power spectrum Pc(u, v) of every pair of sub images is computed by the following standard procedure:

Let image $f_1(x, y)$ is shifted by (Δx, Δy) to get the image

$f_2(x, y)$ given by

$$f2(x, y) = f1(x - \Delta x, y - \Delta y) \text{-----------------(1)}$$

The Fourier Transform of $f_1(x, y)$ and $f_2(x, y)$ should satisfy the following condition:

$$F2(u, v) = F1(u, v)e^{-j(u\Delta x + v\Delta y)} \quad \text{------------------(2)}$$

where $F2(u, v)$ and $F1(u, v)$ are Fourier transforms of

$f1(x, y)$ and $f2(x, y)$ respectively. The normalized cross power spectrum is given by:

$$P_C\ (u, v) = \frac{F1((u,v).F2*(u,v)}{|F1(u,v).F2*(u,v)|} = e^{j(u\Delta x + v\Delta y)} \text{---------------(3)}$$

where * and |.| represent the complex conjugate and magnitude respectively.

Next, the inverse Fourier Transform of $P_C(u, v)$, denoted as $p(x, y)$ is computed, and the peak in $p(x, y)$ is obtained using the Phase Correlation method. The peak gives us an estimate of the spatial offset $(\Delta x', \nabla y')$ between copy-moved regions contained in the two sub images.

The spatial offset $(\Delta x', \nabla y')$ in the sub images, would exactly correspond to the spatial offset by (Δx, Δy) between the copy-moved regions in the original image.

4. If the input image $f_{input}(x, y)$ is shifted by , (Δx, Δy) the shifted image $f_{shift}(x, y)$ can be defined as

$$f_{shift}(x, y) = \begin{cases} f(x + \Delta x, y + \Delta y)\ for\ (x, y) & \in O_{shift} \\ 0 \qquad\qquad for\ (x, y) & \notin O_{shift} \end{cases} \text{--(4)}$$

where $O_{shift}$ represents the overlapping portion in $f_{input}(x, y)$ as shown in Fig. 1

5. Matching segments are obtained by calculating the difference between $f_{shift}(x, y)$ and $f_{input}(x, y)$ as:

$$f_{match}(x, y) = |f_{shift}(x, y) - f_{input}(x, y)| \text{-----(5)}$$

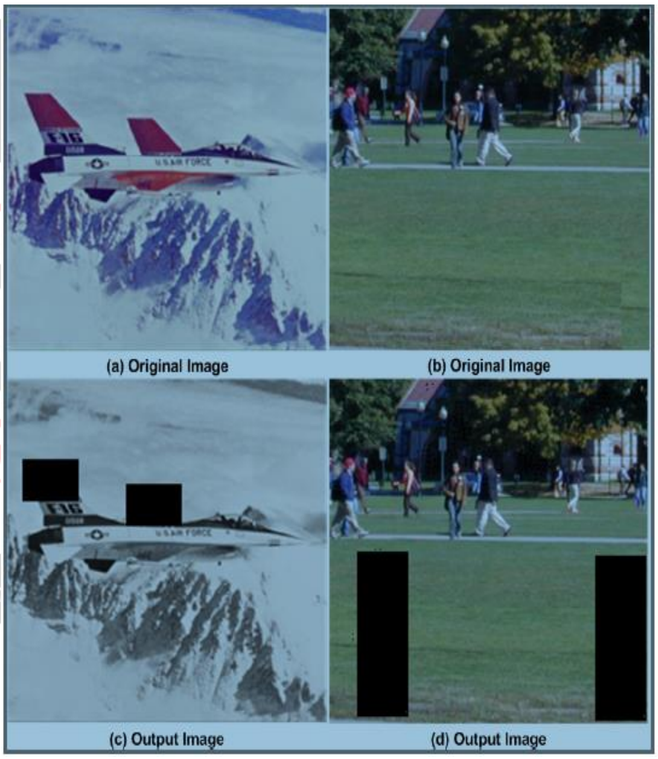


Fig. 2. CWT-FFT Based Copy-Move Forgery Detection. (a)-(b) Original image. (c)-(d) Duplicate Regions Detected.

6. If $f_{match}(x, y) < T$ , where T is user defined threshold, we infer that the corresponding sub-images contain the duplicate regions.

In Fig. 2 the Detection of Duplicate Region Using CWT-FFT Algorithm is shown. Fig. 2(a) -(b) Test images.

The Output Using Proposed Algorithm presented in Fig. 2(c)-(d).

In the next section, the experimental results and analysis are presented in detail.

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## III. EXPERIMENTAL RESULTS & EVALUTION

**Table 1. Comparative Results Of Detection Accuracy.**

| Method | DA (%) (Minimum) | DA (%) (Maximum) | DA (%) (Average) |
|---|---|---|---|
| PCA-DCT Based Method | 90.8874 | 98.9218 | 98.0812 |
| DCT Based Method | 91.8856 | 97.7396 | 97.1023 |
| Improved DCT Based Method | 91.9978 | 98.79010 | 97.0343 |
| Efficient DCT Based Method | 91.0452 | 98.9200 | 98.0108 |
| DyWT Based Method | 93.6267 | 98.7541 | 98.1238 |
| Zernike Based Method | 94.0318 | 98.9674 | 98.0929 |
| Proposed Method CWT-FFT | 95.9860 | 99.3493 | 99.1239 |

**Table 1. Comparative Results Of Detection Accuracy.**

| Method | DA (%) (Minimum) | DA (%) (Maximum) | DA (%) (Average) |
|---|---|---|---|
| PCA Based Method | 89.1452 | 96.9930 | 96.8309 |
| SVD Based Method | 91.3128 | 98.8980 | 98.1076 |

Here, the experimental evaluation results for the proposed algorithm is presented in above section. All implementations are performed in MATLAB Image Processing Toolbox.

We performed our experiment on the test images of size 256_256 pixels collected from **CVG UGR [46] and USC SIPI Image Database [47].**

We have evaluated the performances of the proposed algorithm, and compared them following the benchmark parameters.

**Detection Accuracy (DA)** is directly proportional to number of directly detected copy-move pixels, mathematically given as:

$$DA=\frac{Number\ Of\ Correctly\ Detected\ \ CMP}{Number\ Of\ Pixels\ Actually\ Copy\ Moved}\times 100\%\text{------(6)}$$

CMP: Copy Move Pixels

**False Positive Rate (FPR)** is the proportion of absent events that yield positive test outcomes or proportional to number of falsely detected pixels in copy move region

That is,

$$FPR=\frac{Number\ of\ Pixels\ Falsley\ Detected\ CMP}{Number\ of\ Pixels\ Actually\ Copy\ Moved}\times 100\%\text{ ----(7)}$$

CMP: Copy Move Pixels

**Table 2. Comparative Results Of False Positive Rate.**

| Method | FPR(%) (Minimum) | FPR (%) (Maximum) | FPR(%) (Average) |
|---|---|---|---|
| PCA Based Method | 5.9806 | 8.8729 | 8.0195 |
| SVD Based Method | 5.1087 | 7.8903 | 7.0130 |
| PCA-DCT Based Method | 4.8907 | 6.9695 | 5.9039 |
| DCT Based Method | 6.8769 | 7.9897 | 7.0325 |
| Improved DCT Based Method | 4.2014 | 5.9908 | 4.9859 |
| Efficient DCT Based Method | 3.8650 | 5.9760 | 4.0638 |
| DyWT Based Method | 18.7680 | 21.7089 | 21.0849 |
| Zernike Based method | 11.0287 | 14.8912 | 14.0070 |
| Proposed Method CWT-FFT | 2.01653 | 4.4878 | 4.0619 |

**Table 3. Comparative Results Of False Negative Rate.**

| Method | FNR(%) (Minimum) | FNR (%) (Maximum) | FNR(%) (Average) |
|---|---|---|---|
| PCA Based Method | 1.0956 | 3.718 | 3.1016 |
| SVD Based Method | 1.0978 | 2.0876 | 1.6073 |
| PCA-DCT Based Method | 1.0078 | 1.8400 | 1.1908 |
| DCT Based Method | 1.2980 | 2.7283 | 2.1546 |
| Improved DCT Based Method | 1.0280 | 1.994 | 1.5537 |
| Efficient DCT Based Method | 1.0217 | 1.7692 | 1.4284 |
| DyWT Based Method | 1.5920 | 2.8743 | 1.14507 |

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| Method | FNR(%) (Minimum) | FNR %) (Maximum) | FNR(%) (Average) |
|---|---|---|---|
| Zernike Based Method | 0.8970 | 1.0608 | 0.9829 |
| Proposed Method CWT-FFT | 0.2268 | 0.7992 | 0.6682 |

**False Negative Rate (FNR)** is the proportion to the undetected pixels, presented in duplicate or copy-move region. That is,

$$FNR=\frac{\textit{No of Undetected Copy Move Pixels}}{\textit{No of Pixels Acutally Copy Moved}}\times 100\%\text{------(8)}$$

In our experiments, the performance characteristics of the various techniques presented in Table 1,Table 2 and Table 3, in terms of Detection Accuracy, False Positive Rate and False Negative Rate.

The minimum, maximum and average detection accuracy of are presented in Table 1. From Table 1 it is clear that among all eight state-of-the-art proposed methods CWT-FFT displayed detection accuracy of 99.1239% which is highest among all.

Because of the inherent properties of the CWT-FFT proposed method is an efficient method for feature extraction. Similarly, the results for False Positive Rate and False Negative Rate have been presented in Table 2 and Table 3 respectively.

From Table 2, we can see easily that the false positive rate is trivial for all state-of-the-art.

Our proposed method performed well against False Positive Rate amongst all eight state-of-the-art , methods as is evident from Table 2.

The major challenge in the domain of image forgery detection is to reduce the number of false matches or the False Positive Rate.

From Table 3 it can be observed that the proposed method performed well in case of false negative. It is because of the fact that detection accuracy is directly computed depending on the number of correctly detected

Copy-moved pixels, while the false negative rate is computed according to the number of non-detected pixels in duplicate region.

## IV. CONCLUSION

Meticulous research work has been carried out in the field of Image Forgery detection by profound researchers.

Copy move is the most primitive type of attack on the images .The proposed CWT-FFT algorithm along with phase correlation is discussed in this paper.

Experimental results are tabulated and they validate that the CWT-FFT along with phase correlation technique outperforms latest techniques being implemented by the researchers. The Detection Accuracy (DA),False Positive Rate (FPR) and False Negative Rate (FNR) parameters are used for comparison.

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