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Comparative Analysis of Techniques for Detecting Copy-Move Image Forgery

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Abstract: Various image editing tools available today let alter image content without any expert guidance. Hence, image based crime is increasing at a faster rate than before. Various algorithms exist to detect copy-move forgery in images. In this paper, we compare two popular methods based on DWT and DCT to study and analyze their performance based on execution time and visual results. In both the methods, phase correlation has been applied after respective transformation, as a similarity criterion to estimate the translate offset between two similar regions of an image.

Keywords: DCT (Discrete Cosine Transform), DWT (Discrete wavelet Transform), lexicographical sorting, phase correlation.

I. INTRODUCTION

Forgery has been defined as an intentional falsification of some source in order to deceive others. Forgery is a growing threat to the society which takes on many forms such as signature forgery, document forgery, and image forgery and so on. Of all the forgeries encountered, image forgery always stands as a hot topic to be investigated more about. In terms of image processing, image forgery has been defined as an intentional manipulation of an image to hide some important information from being conveyed to the mass of people or a particular community. The authenticity and integrity of any image is very much needed to be maintained as it can result in interpreting the things or situation in a wrong manner and thereby, leading to communal riots, losing of faith from law and order system and can reflect negative impression of any country to the world. A falsified image can render a society in trouble depending on its information it conveys.

In the broad sense, image forgery has been classified into three categories in order to let understand the type of vulnerability it can cause[7].First being image retouching which is least harmful kind and simply allows enhancement of the content to improve image quality(used in fashion magazines, publication houses etc.).Second is splicing which is mixing of two different images into one. Third and most harmful kind is copy-move image forgery, also known as cloning, where some part of an image is copied and pasted onto the different part of the same image in order to hide some important information or feature. With growing pace of image forgery cases, there is a requirement of some detection approaches which can detect doctored images efficiently. Detection process either uses active or passive approach[12].Active approach requires prior information about the image which is not always possible. Passive approach is the best option to detect forgeries in the images blindly.

Research has continuously been carried out to make detection possible. Fridrich[1] proposed first ever method based on exhaustive search but it was time-taking. It was replaced by block matching approach based on DCT followed by lexicographical sort. Popescu et al.[2] used similar approach but with reduced dimension representation for DCT blocks by applying PCA.Li et al.[4] applied DWT with singular value decomposition(SVD) to detect forgery in the image. Ghorbani et al.[9] proposed QCD(DWT-DCT) based method.DWT was applied to the image followed by DCT. Shift vector was computed to find forgery. Zimba et al.[10] applied DWT with radix sort to reduce execution time as compared to DWT with lexicographical sort.

In this paper, we compare two techniques based on DWT and DCT. The rest of this paper is organized as follows: in section II, methodology is described for both the methods. In section III, we present the comparative results and section IV concludes the work.

II. METHODOLOGY

According to previous existing approaches, there is a issue of time complexity. Both DWT and DCT are capable to find copy-paste content from an image but execution time still remains a great challenge.

A) Overview of DWT based method

We design a new algorithm which is basically based on error acceptance logic.There are lots of application where errors can be easily accepted by human eyes(human eye is not capable to detect error in the range of 5-10% in any graphical based content).Our algorithm can be rather treated as approximate discrete wavelet system.

1) **Input image:** The algorithm takes in, suspected image as input. Image is a color image of size mxm.
2) **Conversion to YCbCr color space:** Color image consists of three channels: red, blue and green. Study shows human eyes are sensitive to luminance but not so sensitive to chrominance. In order to simplify the

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process of detection, it is converted to YCbCr space and finally, Y-component (luminance part) is used for further processing.

Conversion from RGB to YCbCr space is carried out according to the formula:

$$Y = 0.299R+0.587G+0.114B$$
$$Cb = 128-0.168736R-0.331264G+0.5B$$
$$Cr = 128+0.5R-0.418688G-0.081312B$$

3) **Wavelet decomposition of the image:** Apply two-dimensional wavelet decomposition to the input image to decompose it into four sub-images.The sub-images are labeled LL,LH,HL and HH.LL corresponds to approximation image.LH,HL,HH correspond to the vertical,horizontal and diagonal components of the image respectively.These sub-images can be combined to obtain original image.Decomposition results in reduction of the size of image at each level.
4) **Reduction of the coefficients:** Our approach does not require exact brightness information.So,we reduce all the coefficients(approximate and detailed) to half.By reducing the coefficients,we are still able to detect copy-paste area with small error acceptance.
5) **Reconstruction of the image:** We reconstruct the original image with these reduced coefficients.
6) **Block sliding:** Slide a bxb block(here 4x4) over the image to obtain $(m-b+1)^2$ overlapping blocks.
7) **Block arrangement:** Arrange $(m-b+1)^2$ blocks into a matrix 'A' in row-wise manner.Form another matrix 'B' with two additional columns with respect to matrix 'A' to store top-left coordinates.
8) **Row sorting:** Sort the rows of matrix 'A' lexicographically.Lexicographical sorting re-arranges the matrix to bring similar and identical rows adjacent to each other.
9) **Phase correlation:** Template matching is best achieved with phase correlation.It uses a fast frequency domain approach to estimate the relative translative offset between two similar images.The result of applying correlation between two images is an image which has peak intensities at locations where two images match the best. Ratio 'r' between two images 'im1' and 'im2' can be computed as:

$$r = \frac{F(blk1) \times conj(F(blk2))}{\|F(blk1) \times conj(F(blk1))\|}$$

Here,'F' represents fourier transform and 'conj' represents complex conjugate.
Phase correlation is computed as inverse fourier transform of 'r':

$$P = F^{-1}(r)$$

For detecting copy-move forgery,phase correlation for the block corresponding to the current row is being computed with the block corresponding to the next row.

10) **Detection:** If computed phase correlation value exceeds the threshold 't' that is being set, then, top-left coordinates taken from matrix 'B' of both the blocks are stored in a new row of a matrix. Region corresponding to the above image are marked as copy-moved area.

B) Overview of DCT based method

1) **Input image**: Algorithm takes a color image as an input to be able to detect copy-moved regions,if exists.
2) **Conversion from RGB to YCbCr color space** : Image is converted from RGB color space to YCbCr space in order to extract the luminance part.
3) **Block sliding**: Slide a bxb block(here 8x8) by one pixel over the image from upper left corner to the bottom right corner to form $(m-b+1)^2$ overlapping blocks.
4) **DCT application**: Apply two-dimensional DCT to every block.DCT is being used in many compression applications due to its ability to represent details with fewer coefficients.
5) **Block arrangement**: Likewise done in step 7 of DWT method,arrange these overlapping blocks into a new matrix 'A' row-wise.
6) **Lexicographical sorting**: Sort the rows of matrix 'A' lexicographically.
7) **Phase correlation**: Compute the phase correlation between the two adjacent blocks to be able to detect copied and moved area in the image.
8) **Detection**: For those blocks whose phase correlation exceeds the preset threshold't',mark the respective areas in the image by getting the coordinates from matrix 'B'.

C) General flow diagram

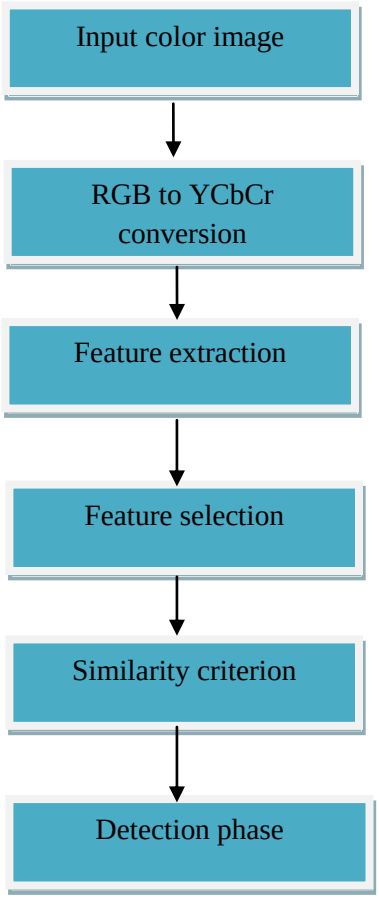

Figure 1: Flow diagram for both DCT and DWT method

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III. EXPERIMENTAL RESULTS

The algorithms were coded in MATLAB R2009a on a system equipped with Intel dual core 1 GHz processor with 1 GB RAM. Images used for comparison are of size 256x256.Comparison is being carried out on the basis of execution time, feature vector dimension, number of overlapping blocks. We had a dataset of 20 forged images out of which analysis with 5 images has been shown in this paper.

a) Comparison based on execution time

Parameter	DWT method (in seconds)	DCT method (in seconds)
Image 1	3.34	6.88
Image 2	3.62	7.23
Image 3	3.29	6.65
Image 4	3.26	6.65
Image 5	3.27	6.74

Table 1: Execution time comparison

Analysis of the table presented above shows that DWT based method is far better in achieving reduction in execution time.An approximate idea of the related forged area is being presented with considerable reduction in execution time with the help of small block sliding and error acceptance logic.

b) Comparison based on visual results

Visual results reveal that DWT as well as DCT both provide better detection result.DWT with small block size and reduction in time complexity is able to produce almost better visualization of the forged area.Detection accuracy is slightly more in case of DWT method as compared to DCT one.

Figure 2: Original image

Figure 3: Forged image

Figure 4: Detection by DWT method

Figure 5: Detection by DCT method

c) Comparison based on features

Analysis of the above table clearly shows reduction in feature vector dimension but slight increment in number of blocks in DWT method as compared to DCT method.

Method	Block Size	Block numbers	Feature vector dimension
DWT	4x4	64009	16
DCT	8x8	62001	64

Table2. Feature comparison

Block size could not be made same in order to improve the detection result in case of DCT method.

IV. CONCLUSION

In this paper, we have compared two classical methods of detecting copy-move forgery in images. The main challenges being faced by any detection algorithm are setting threshold, reduction in execution time, decreasing number of overlapping blocks and reducing feature vector dimension. Threshold setting is not automatic rather manual, found either by hit and trial or with experience. In the recent years, researchers have strive on reducing the time complexity with highest accuracy but post processing operations like rotation, scaling, JPEG compression and noise addition poses a big threat to the existing algorithms. In future, we aim to apply our algorithms against post-processing operations done on the forged image.

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