Fast Detection of Forgery Image using Discrete Cosine Transform Four Step Search Algorithm

Yong-Dal Shin*, Yong-Suk Cho**

ABSTRACT

Recently, Photo editing softwares such as digital cameras, Paintshop Pro, and Photoshop digital can create counterfeit images easily. Various techniques for detection of tamper images or forgery images have been proposed in the literature. A form of digital forgery is copy-move image forgery. Copy-move is one of the forgeries and is used wherever you need to cover a part of the image to add or remove information. Copy-move image forgery refers to copying a specific area of an image itself and pasting it into another area of the same image. The purpose of copy-move image forgery detection is to detect the same or very similar region image within the original image. In this paper, we proposed fast detection of forgery image using four step search based on discrete cosine transform and a four step search algorithm using discrete cosine transform (FSSDCT). The computational complexity of our algorithm reduced 34.23% than conventional DCT three step search algorithm (DCTTSS).

Key words: Duplicated Forgery Image, Discrete Cosine Transform, Four Step Search Algorithm

1. INTRODUCTION

Digital cameras and smart phones, and digital image processing software such as Photoshop, Paintshop Pro, you can duplicate digital counterfeit images relatively easily [1–14].

A variety of algorithms for detecting duplicated forgery images or tampering images have been proposed in many papers [1–14]. A technique of digital image forgery is copy-move image forgery. Copy-move image forgery is a method of forging an image by copying a specific image area of the image itself and then attaching it to another area of the same image [1–14]. The purpose of copy-move image forgery detection is to detect the same or very similar region image within the original image.

An example of copy-move forged image is showed by Fig. 1 (a) and (b), and each of Fig. 1(a)

and Fig. 1(b) shows an original image and a copy-moved forged image respectively.

J. Fridrich [1] proposed an exacting match method for the forged image detection of a copy-move forged image. J. Fridrich [1] studied detecting copy-move forgery image and explaining an efficient and reliable detection method. This method can successfully detect the forged image part

<table>
<thead>
<tr>
<th>(a) Original image</th>
<th>(b) Copy-move forgery image</th>
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Fig. 1. Conception of copy-move forged image.

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even if the copied area is enhanced/modified [1].

Popescu [2] proposed Principal Component Analysis (PCA) to reduce the representation of dimensions in image blocks [9]-[12]. We presented an efficient and robust technology that automatically detects duplicate areas of an image. This technique works by applying PCA first on a small fixed-size image block to produce a reduced dimension representation. Detection of copy-forgery has become one of the areas studied in blind image forensics. Christlein etc. [3] proposed that copy-move forgery detection methods and processing steps are in various post-processing methods. The point of [3] is to evaluate the performance of previously proposed feature sets [3].

Most of the copy-move forgery image detection methods are divided by overlapping blocks in the matching search area [1-14]. The N×N image size data is divided into (N-B-1)3 overlapping blocks having block size of B×B in order to match of copy-move forgery image detection [6], [9-14].

The exhaustive search method require huge computational complexity to match forged block in the copy-move forgery image detection [1-4], [9-14]. However, Shin [11]-[14] proposed low complexity algorithms to match forged block. Shin [11-14] proposed a fast detection method of the copy-move forgery image using DCT and spatial domain. The proposed algorithm reduced computational complexity, when compared to the conventional various copy-move forgery detection methods.

In this paper, we proposed a four step search fast detection of forgery image using discrete cosine transform. We proposed a new four step search using discrete cosine transform (FSSDCT). The computational complexity of our algorithm reduced 34.23% than conventional three step search algorithm using DCT (TSSDCT).

2. THE PROPOSED METHOD

Copy-move forgery image is shown in Fig. 2.

From the Fig. 2, C block image is copy image of the original image \( I(i,j) \), \( I(P) \) is copy-move forgery image block. We have an original image \( I(i,j) \) by shifting motion vector \( (x, y) \), we can get the forgery image \( I(P) \), such that[9]

\[
I(P) = I(i-x, j-y)
\]

The C block and P block of the Fig. 2 show copy block and pasted block respectively. The Fig. 2 is copy-move forgery image by shifting motion vector x and motion vector y.

We proposed a fast detection method of forgery image using four step search algorithm using discrete cosine transform (DCT) (FSSDCT) to reduce computational complexity. The Koga et al [15] proposed the three step search algorithm (TSS) for motion estimation in the spatial domain [9-12]. The TSS algorithm of video has been widely used for motion estimation due to its simplicity and excellent performance.

We proposed four step search algorithm using DCT (FSSDCT). Our FSSDCT algorithm works as follows. Our algorithm obtained DCT coefficients of 8×8 pixel block for FSSDCT in the frequency domain. The DCT algorithm [16] converts the image/video signal in the spatial domain into the image/video signal in the frequency domain [9-12]. Most of image/video signal energy lies in the DC and low frequency region [1]. These represent the DCT DC (0) and three (1, 2, 3) coefficients of Fig. 3 [14]. The high frequency of the DCT do-

![Fig. 2, Motion vector x and y of copy-move forgery image.](image-url)
The motion coefficients are shown in Equation (2) [16].

$$X(u,v) = \frac{2}{B} C(u) C(v) \sum_{i=0}^{B-1} \sum_{j=0}^{B-1} x(i,j) \cos \left( \frac{(2i+1)\pi u}{2B} \right) \cos \left( \frac{(2j+1)\pi v}{2B} \right)$$

(2)

Inverse DCT (IDCT) is

$$x(i,j) = \frac{1}{B^2} C(u) C(v) \sum_{u=0}^{B-1} \sum_{v=0}^{B-1} X(u,v) \cos \left( \frac{(2i+1)\pi u}{2B} \right) \cos \left( \frac{(2j+1)\pi v}{2B} \right)$$

$$C(0) = 1/\sqrt{2}, C(u) = C(v) = 1 (u = 0, v = 0), \text{where } B \text{ is a blocksize}$$

(3)

The DCT transform coefficient DC value for $u=0, v=0$, is the average value of the DCT transform domain for the spatial domain $B \times B$ pixel block, where $B$ is the $8 \times 8$ pixel block [10]. AC coefficients of the DCT transform domain are all other coefficients except the DC value.

The proposed algorithm try to find copy-moved motion vectors in the forged image using FSSDCT. The copy-moved motion vectors of forged image can be obtained by using FSSDCT, which reduces computational complexity. It will be described in detail the proposed method in the following.

Step 1: We use the DCT transform of Eq. (1) to compute the DCT coefficients from the forged input image by $8 \times 8$ pixel blocks [10]. The FSSDCT algorithm starts with a check point with the center of the DCT coefficient $(0,0)$ in Fig. 3 and measures the horizontal and vertical lines for nine check points with a step size(SS) of $SS=4$, (4 pixels / 4 lines) in order to find copy-moved forged block image, and four-step search algorithm is performed around black check point. Find the minimum check point by calculating equation (4) from the nine check points. From Fig. 3, the minimum check point is $(–4,–4)$.

Step 2: From Fig. 3, Eight check points are set based on the DCT coefficient position of the check points $(–4,–4)$ found in step 1, and the step size is set to 3, 3 pixel / 3 line in step 2. After performing FSSDCT on the eight check points, find check points satisfying minimum of equation (4). From step 2, the minimum check point is $(–7,–7)$ in Fig. 3.

Step 3: From Fig. 3, Eight check points are set based on the DCT coefficient position of the check points $(–7,–7)$ found in step 2, and the step size is set to 2, 2 pixel / 2 line in step 3. After performing FSSDCT on the eight check points, find check points satisfying minimum of equation (4). From step 3, the minimum check point is $(–9,–9)$.

Step 4: From Fig. 3, Eight check pointers are set based on the DCT coefficient position of the check points $(–9,–9)$ found in step 3, and the step size is set to 1, 1 pixel / 1 line in step 4. After performing FSSDCT on the eight check points, find check points satisfying minimum of equation (4). From step 4, the minimum check point is $(–10,–10)$. The best-match block $(–10,–10)$ in the step 4 is found. The best-match check point of DCT coefficients location is the copy-moved motion vector value $(–10,–10)$.

The computational complexity of FSSDCT algorithm needs 33 DCT coefficients check points. In the case of a maximum displacement window of 10 i.e. $w=–10 \sim +10$, the total number of checking points required is $9(\text{Step 1}) + 8(\text{Step 2}) + 8(\text{Step 3}) + 8(\text{Step 4})$. 

![Fig. 3. Algorithm of the DCTFSS,](image)
3) \(8\) (Step 4) or 33 for search window 21\(\times21\) DCT coefficients. On the other hand, check points of the exhaustive search method need 441 check points to search motion vector of copy-move forgery image.

We used block difference (BD) for matching of copy-moved forgery image detection based on FSSDCT. In order to search motion vectors \(x\) and \(y\) of copy-moved image forgery, we found minimum of block difference (BD) of eq. (4) based on FSSDCT.

\[
BD = \min \sum |DF(i+ii, j+jj) - DF(i+ii+x, j+jj+y)|
\]

(4)

\(DI(i+ii, j+jj)\) is DCT coefficients of block at the position \((i, j)\) of reference image, where, \(i=0,1,2,3\ldots N-B-1, j=0,1,2,3\ldots N-B-1, ii, jj=0,1,2,3\). \(DF(i+ii-x, j+jj+y)\) are DCT coefficients of block at position \((i+ii, j+jj)\) of the matching search image, and the motion vectors \(x\) and \(y\) of copy-moved forgery image obtained by FSSDCT. We used 10 pixels for maximum displacement window of FSSDCT. The test image is 8 bits/pixel and \(256\times256\) pixels, and block size is 8\(\times8\) pixel block. The FSSDCT is divided into non-overlapping 21\(\times21\) pixel blocks to search motion vector \(x\) and \(y\) of copy-move forgery image block in the matching search block image. Thus, the computational complexity is reduced to 4 instead of 64 in an 8\(\times8\) pixel block to obtain the motion vector \(x, y\) in the FSSDCT. The

\[0\quad 1\]
\[2\quad 3\]

Fig. 4. One DC (0) and three (1,2,3) low frequency coefficients.

ii and jj in Equation (4) require the 4-computational complexity indicated by 0,1,2,3 in Fig. 4. Hence, the BD of FSSDCT reduces computational complexity.

\[
\text{If ( BD == 0)}
\]

Copy-moved image forgery block (5)

\[
\text{Else}
\]

Not copy-moved image forgery block

The proposed method is four step search algorithm using DCT. The flowchart of the proposed method FSSDCT is shown Fig. 5. From equation (5), if BD is 0, the copied block is the same as the moved block, so that is the copy moving counterfeit block image [11–14]. If BD is not 0, the copied block image is different from the attached block image, so the block image is not a duplicate move counterfeit block [11–14].

3. EXPERIMENTAL RESULTS

We proposed a fast detection algorithm for copy-moved forgery image using four step search algorithm by discrete cosine transform (FSSDCT). The proposed FSSDCT method reduces computa-
The test image for the simulation, Bridge, Car3, and Airplane images are 8 bits and the resolution is 256×256 pixels [17]. The matching search area of the test image is divided into 21×21 which does not overlap from the first position (0,0) of the image to the last image position (255,255). BD of copy-moved image forgery detection is Equation (4) based on FSSDCT method.

In this paper, the computational complexity of the FSSDCT algorithm requires four DCT coefficients for the 21×21 pixel block matching search per checking point. In order to reduce computational complexity of the proposed FSSDCT algorithm, one DC and three low-frequency DCT coefficients per check point are sufficient instead of 64 check points in an 8×8 pixel block.

Table 1 shows the computational complexity and compares the proposed FSSDCT algorithm with the existing methods. The proposed fast FSSDCT algorithm detected 99% of copy-move forgery images.

From Table 1, IR, BS, MSACP, PD, CC are image representation, block size of reference region, matching search area checking points number, feature dimension, computation complexity (based on reference[1]) method, respectively.

The proposed FSSDCT algorithm reduced 99.52% of computational complexity than exhaustive search [1]. As shown in Table 1, the proposed FSSDCT method reduces the computational complexity compared to the conventional method [1, 2, 7], because the FSSDCT method used DC and three low frequency DCT coefficients which characteristic of DCT compression in the frequency domain, and it is a matching search area -10×-10, non-overlapping 21×21 pixel block.

The Fig. 6, 7, and 8 showed performance of proposed method. Figures showed original images, copy-moved image forgery, detection of copy-move image forgery in the Fig. 6, 7, and 8. From the Fig. 6(c), left black box is copied, right black box is moved to image forgery block. From Fig. 7(c) and 8(c), right black box is copied, left black box is moved to image forgery block. From Fig. 6, 7, and 8, our algorithm detected above 99% copy-move image forgery. Copy-move forgery image detection rates of Bridge, Car3, and Airplane are 99.70%, 99.17%, and 99.01%, respectively. Detection rate of copy-move forgery image (DR) is expressed by equation (6).

\[
DR = \frac{DPN}{TPN}
\]

where, detected pixel number of copy move image (DPN), total pixel number of copy move image (TPN).
4. CONCLUSION

we proposed fast detection algorithm of forgery image using four step search based on discrete cosine transform. We proposed a new four step search using discrete cosine transform (FSSDCT). The computational complexity of our algorithm reduced 34.23% than conventional three step search algorithm using DCT (TSSDCT).

REFERENCE


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