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# Double JPEG Compression Detection Using Statistical Analysis

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**Abstract**

Nowadays with advancement of technology, tampering of digital images using computer and advanced software packages like Photoshop has become a simple task. Many algorithms have been proposed to detect tampered images that have been kept developing. In this regard, verification of accuracy of image content and detection of manipulations in image regardless of any previous knowledge about the image content and can be an important research field. Recently, many efforts have been made in the area of image forensics, especially passive algorithms for detecting tampered images. JPEG format is one of the most common formats used for image compression. Hence, JPEG images are subjected to attacks such as manipulation and cropping. Since single compressed and double compressed JPEG images contain blocking artifacts, therefore these images can be detected by assessment of these artifacts. JPEG artifacts will be not aligned in double compressed images which have been manipulated. This paper intends to examine challenges existing in blocking artifact extraction and improve the detection of double compressed JPEG images. Results of experiments show that new proposed approach has a proper functionality.

***Keywords:*** *Detection of double JPEG compression, Digital Image* Forensics, *Image manipulation, Validation originality image, Detection image manipulate.*

## 1. Introduction

Rapid growth of image processing software and advancement of digital cameras have resulted in manipulated images to a large extent, of which there has not existed any trace, concluded that numerous demands have emerged to detect algorithms performing automated authenticity analysis of JPEG images for the purpose of determining accuracy of these images. Unfortunately, the tools which are used to edit image are occasionally misused or forged. There are active and passive approaches for image authentication at the area of digital images. Concerning active approach, information is hidden in the image, yet if tangible changes occur in the image, the embedded information seems as a signature on the image. If the person manipulates the image, the embedded information will be manipulated, because the information hidden in the image loses its content in a manipulated image. Passive detection techniques use the received image that is solely used to assess accuracy of image, regardless of receiving digital signature or lock code in the original image from the transmitter. This technique has been grounded on this assumption that however visual effects might not emerge in digital image forgery via this technique, it can disturb statistical properties of the original image [1,2]. Nowadays, statistical tools have been regarded as the prominent tools to detect forged images. POPESCU [3] preferred use of statistical tools to detect forged images.It should be noted that CHANG et al. [4] and LI et al. [5] followed by POPESCU [3] have been mentioned of those ones who have engaged at this area. Using statistical tools, they detected whether double image compression is active or passive on a histogram of coefficients of discrete cosine transformation of an image. POPESCU [3] has mentioned his main idea to detect double image compression in this way that if an image is double-compressed, firstly discrete cosine transformation is applied on coefficients of this image under the same situations and then fourier transformation is applied on the considered coefficients, then it can detect whether the considered image is compressed or not. If some impacts manifest in fourier transform in the frequencies, it can deduce whether the considered image is compressed or not. There will be some challenges in the proposed method, of which it can refer to this challenge that such a method will be suitable only for aligned images. Another challenge will be in this way that if the image with high quality undergoes compression and then an image with low quality undergoes a double compression, detection of image will be much more difficult. Another fundamental challenge in the algorithm lies on this fact that it cannot stand against the attacks, i.e. the attacks include magnification of the image, cropping image and so forth, yet it can state that this algorithm has been the starting point in the statistical tools. LEI et al. [6] proposed a simple and reliable algorithm to detect JPEG compressed images. When the image is compressed, it will have a series of blocking artifacts, that they will be witnessed even if the high-quality image is compressed. If the border between once compressed images and the border between double compressed images do not be aligned, it can announce that the compressed image has been non-

aligned. The method proposed by LEI et al. [6] calculates the difference between each pixel and the pixels in surrounding. The main challenge in this method lies on this point that if the pixel values on border be in a way to get close to zero or equal to zero, then the blocking pixel is considered by mistake, yet the pixel is on the border of block. Ultimately, another challenge in this method lies on detection of pixel on border and also on this point that blocks can be solely detected at flat areas.
A simple and reliable algorithm has been proposed by LIN et al. [7] in order to detect aligned and non-aligned double compressed images based on Bayesian approach concerning detection of double compressed image via manipulation. There are no periodic patterns in once compressed images, yet periodic patterns prevail in double compressed images. The important point lies on this fact that histogram of original images which are not manipulated has the periodic pattern. On the other hand, histogram of manipulated images has no periodic pattern. Firstly, Lin examines whether histogram of coefficients of discrete cosine transformation in (i,j) has a periodic pattern or not, yet it must draw into attention that histogram of coefficients is a mixture of double compressed and once compressed coefficients. Concerning histogram of coefficients of discrete cosine transformation, LIN et al. [7] examines that the peaks in histogram which are higher than rest of peaks in histogram are more likely in the regions which have not undergone change or have undergone double compression. The fundamental challenge in this method lies on this fact that it cannot represent an accurate estimation in a series of states, e.g. assume that the image is true, yet it is not at the higher peak and the block which has been manipulated has stationed at higher peak, as the result this method considers the true block as the destroyed block and the destroyed block as the true one, thereby it cannot represent a true estimation. Hence, PIVA [8] modified the probability calculation method so as to represent a true estimation for the destroyed and true blocks. Using random selection, HUANG et al. [9] detected the points in the image which have been undergone a non-aligned manipulation.

PIVA et al. [10] examined detection of non-aligned double JPEG compression based on integer periodicity maps, that such a method will be examined in a concise. According to the proposed methods, non-aligned double compressed images are precisely detected, yet detection of aligned once compressed and double compressed images is not possible. Li et al. [11] proposed a statistical method based on Benford's law [12]. Detection of once compressed images based on Benford's law [12] has a descending pattern, yet detection of double compressed images does not follow this law. One of the most fundamental challenges in this method lies on this point that the proposed method is the only method to detect double compressed images, thus it must examine whether the proposed method can be applied for the manipulated and cropped images or not.

## 2. Proposing new approach

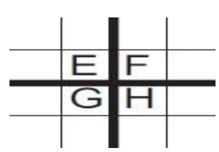
Most of the methods elaborated in previous section can detect the double compressed images in case the image has been once compressed and undergone compression for the second time with high quality. The aforementioned methods are used through double JPEG compression, discrete cosine transformation and fourier transformation to detect double compressed images, yet the fundamental challenge lies on this point that if the image undergoes compression more than one time, whether the aforementioned methods can detect the image forgery or not. Hence, concerning the proposed method, an optimal method is elaborated to detect double compressed images and double compressed images together with manipulation or cropping. In following, various stages of the proposed method are explained.

### 2.1 Pixel Difference

As mentioned above, compressed images together with manipulation and cropping will be followed by block artifacts. QUEIROZ et al. [13] used blocking effects for the first in order to detect double compressed images. SUN et al. [14] detected blocking artifacts in double compressed images. Using first derivative method, equation 1 extracts blocking artifacts in the double compressed images.

$$f(x,y)=\left|I(x,y)+I(x+1,y+1)-I(x+1,y)-I(x,y+1)\right| \tag{1}$$

After calculating difference in pixels via equation 1, the values will be equal to zero or larger values which indicate the values inside the block and border or block. As stated, the values at the border of block represent larger values; now imagine the values inside the block in a way that the calculation time via equation 1 occurs in contrast with the what aforementioned, i.e. the values at the border of block equal to zero, whereby this will be accounted as a challenge, because border of block will be no longer detected. Figure.1 represents a sample for this challenge.




$$f=\left|E+H-F-G\right|$$
$$E=50, H=70, F=70, G=50$$

Figure.1 A sample of appearing zero values at the border of block

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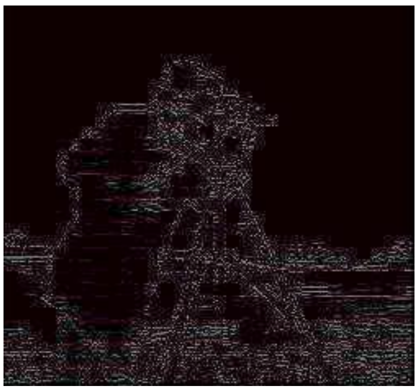
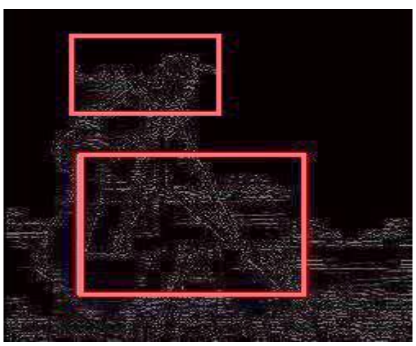
To optimize this challenge via equation 2 (second derivative), the border of block is almost detected properly.

$$f(x,y) = \left|2I(x,y) - I(x-1,y) - I(x+1,y)\right| \quad (2)$$

To implement the equation above, values greater than 50 must be removed so as to specify blocking artifacts precisely, because values greater than 50 represent values with noise causing a challenge in detection of blocking artifacts. Figure. 2 represents output of implementation.



(a)

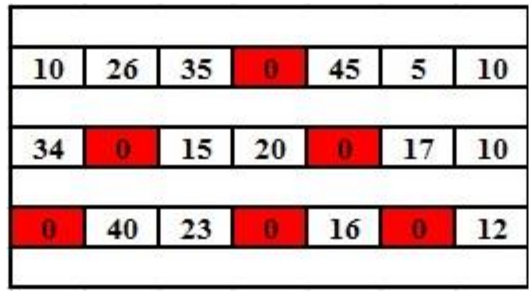


(b)

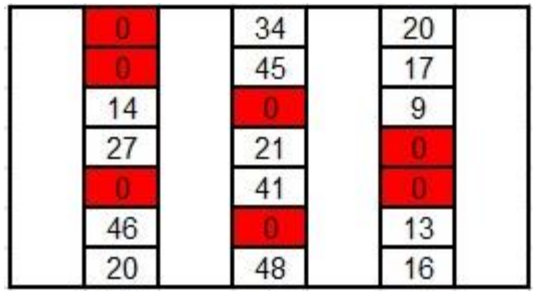
Figure.2 a- Output at the mode 50-70 without image manipulation , b- Output at the mode 50-70 with image manipulation (the manipulation area has been specified via red color)

## 2.2 Artifacts at vertical and horizontal mode

At stage 1, blocking artifacts were almost extracted, yet as shown in Figure.2 this stage still requires optimization. In this stage, vertical and horizontal lines are doubled extracted.




(a)




(b)

Figure.3 a-extraction of blocking artifacts at horizontal mode, b-extraction of blocking artifacts at vertical mode

At the first step, blocking artifacts at vertical and horizontal modes were almost extracted, yet this extraction might not be optimal, e.g. dashed lines are seen in Figure.3 (a & b), yet dashed lines are not seen in blocking artifacts, and this can be a challenge in extraction of vertical and horizontal lines. In following, another pattern is suggested for optimization at this stage. As shown in Figure.3, zero values represent dashed lines in blocking artifacts, that these values must be removed and replaced with non-zero values; as the result, it can remove dashed lines from vertical and horizontal lines in blocking artifacts. To remove these values which have undergone dashed lines in blocking artifacts, it can use an accumulator in a way to be able to remove zero values. The accumulator works out in this way that it sums sixteen pixels followed by each pixel and sixteen pixels before this pixel and transmits the sum on this pixel, whereby the zero values are removed. Equation 3 and 4 represent how an accumulator works out on vertical and horizontal blocking artifacts.

$$f_{AccV} = \sum y - 16 \le i \le y + 16 \quad (3)$$

$$f_{AccH} = \sum x - 16 \le i \le x + 16 \quad (4)$$

Figure.4 represents an image followed by applying the accumulator on vertical and horizontal blocking artifacts.

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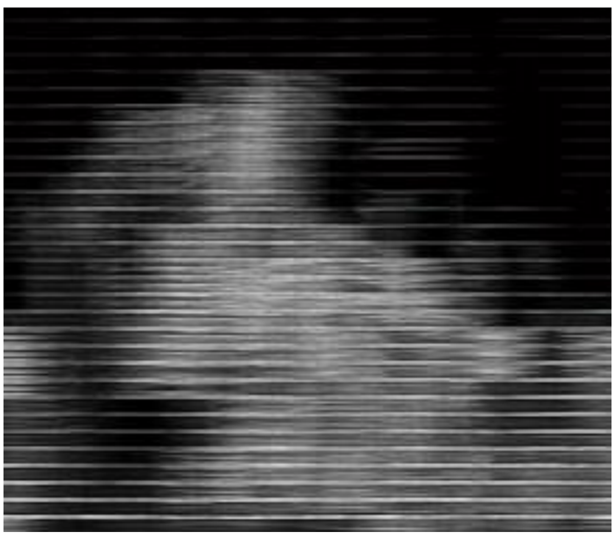
(a)



(b)

Figure.4 a- Extraction of vertical blocks followed by applying accumulator, b- Extraction of horizontal blocks followed by applying accumulator

## 2.3 Removal of error values in blocking artifacts

At the stage applying with accumulator, the zero values or the values caused dashed lines in vertical and horizontal blocking artifacts were removed, yet non-integral values were possible to exist between the values representing blocking artifacts such as noise agents and such agents. In following, another pattern is suggested for optimization at this stage. It can median filter to remove non-integral values in a way to apply median filter on non-integral values. Median filter is separately applied on vertical and horizontal blocking artifacts. To apply median filter in a proper way, five values are considered for the considered filter. Equations 5 and 6 represent how median filter is applied on vertical and horizontal blocking artifacts.

$$f_v(x,y) = MedianFilter\{i = y-16, y-8, y, y+8, y+16\} \quad (5)$$

$$f_h(x,y) = MedianFilter\{i = x-16, x-8, x, x+8, x+16\} \quad (6)$$

After applying equations 5 & 6, non-integral values among vertical and horizontal blocking artifacts are removed and replaced with small values. In equations 5 & 6, five values are compared, yet it can compare values greater than 5 pixels, under which there will be no difference.

## 2.4 Removal of error values in blocking artifacts

After applying all the aforementioned stages, now a final matrix representing sum of vertical and horizontal blocks must be obtained. To acquire vertical and horizontal blocking artifacts, it requires summing two vertical and horizontal matrices so as to acquire final matrix. Equation 7 represents sum of vertical and horizontal blocks and Figure.5 represents final matrix for sum of vertical and horizontal blocks.

$$f_{VH}(x,y) = f_v(x,y) + f_h(x,y) \quad (7)$$

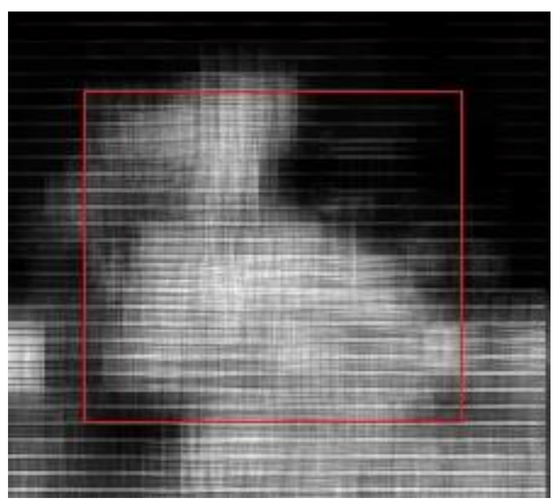


Figure.5 Sum of vertical and horizontal blocking artifacts (red rectangular represents the manipulation area)

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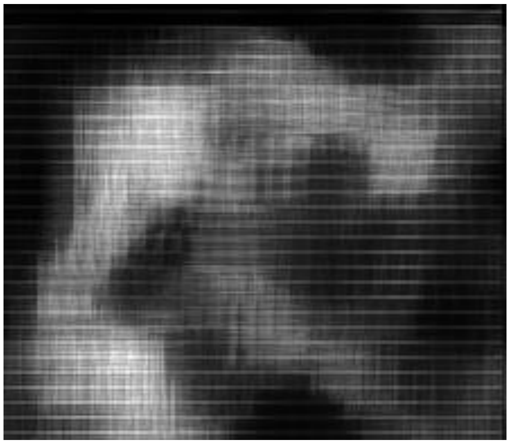
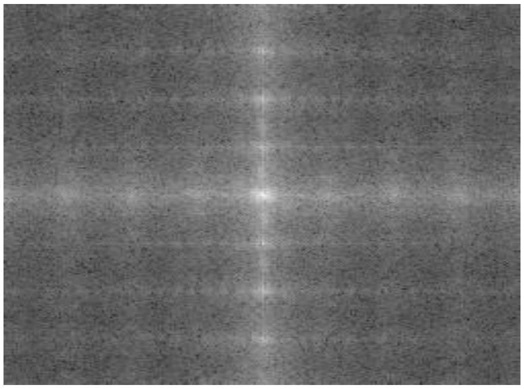
### 2.5 Feature Extraction

At previous stages, an optimal method was proposed to acquire blocking artifacts. It must be taken into account that such an action must be applied on once compressed images and double compressed images so as to acquire a pattern for comparison. Using two-dimensional fourier transformation, a pattern is obtained to compare once compressed images and double compressed images. Firstly fourier transformation is obtained through the final image so as to make the calculations on fourier transformation. After obtaining two-dimensional fourier transformation as a presumption from central part of matrix, a matrix (11*11) is extracted because it can extract a pattern for comparison from this matrix. Figure.6 represents two-dimensional fourier transformation of a double compressed image with quality factor 50 and once with quality factor 70.



(a)



(b)

Figure.6 Two-dimensional fourier transformation on double compressed image with quality factor 50-70; a-image of blocking artifact, b- two-dimensional fourier transformation on the blocking artifact image

Selection of matrix (11*11) is assumed as a presumption, that it can select the matrix in larger dimensions such as 23*23 and/or 33*33. Figure.7 represents selection of matrix 11*11 at the center of two-dimensional fourier transformation.

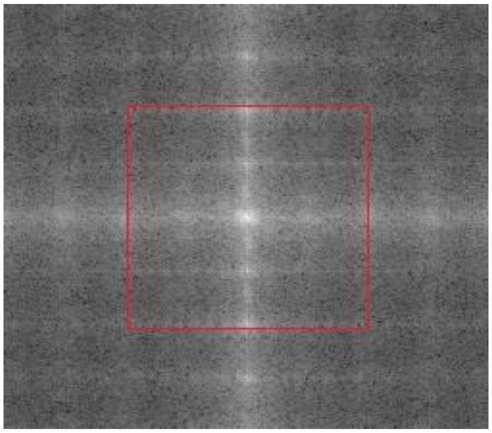


Figure. 7 Selection of central matrix in two-dimensional fourier transformation

To calculate feature, three parameters of mean, variance and entropy via selected matrix are used. To calculate these three parameters, there non-overlapping areas are selected and the calculations are applied on these areas. Figure.8 represents these three non-overlapping areas.

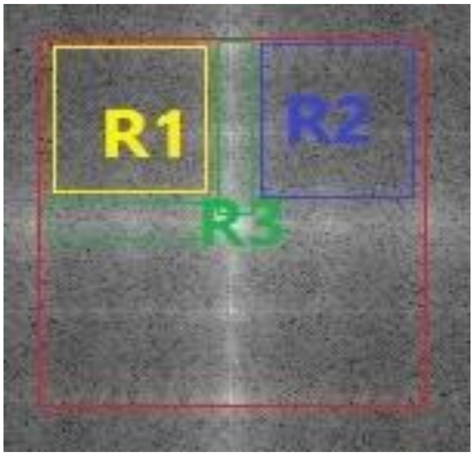



Figure.8 selection of non-overlapping areas to calculate three parameters of mean, variance andentropy

After selection of three non-overlapping areas, equations 8, 9 and 10 are calculated so as to extract three eigenvalues from matrix 11*11 undergoing two-dimensional fourier transformation.

$$F_{Mean(S-D)} = \frac{Mean(Ri)}{Mean(R3)}, i = 1,2 \quad (8)$$

$$F_{Variance(S-D)} = \frac{Variance(Ri)}{Variance(R3)}, i = 1,2 \quad (9)$$

$$F_{Entropy(S-D)} = \frac{Entropy(Ri)}{Entropy(R3)}, i = 1,2 \quad (10)$$

## 3. Experiments and Results

### 3.1 Settings

In the experiment through the proposed pattern, 31 images preferably in grey color are selected among the images in software Matlab to train the pattern and 50 images are selected among the images in software Matlab to test the proposed pattern. All the selected images are shown with format bmp, yet it can select the selected images with format tif, because these formats represent those formats of the images which have not been compressed [15]. To select images, it has been strived to select the images by length of 256*256 and 512*512. In this research, all the implementations have been fulfilled via software Matlab-2014. Further, all the results from the experiments have been obtained through implementation of this algorithm on a computer with 2.5 GHz Dual-core Intel Core i5 processor and 6 GB of RAM. Since the implementation duration for the proposed pattern is very high, parallelization technique has been used to implement the pattern.

### 3.2 Results

To examine extraction of once compressed images and double compressed images with and without manipulation and cropping, extraction of data attributes in the once compressed images compared to double compressed images will have more data dispersion, thus this pattern is used to detect compressed images. In this experiment, a number of grey bmp images were selected to test the pattern so as investigate accuracy of function compared to the recently proposed methods.

Table 1 represents accuracy of proposed methods by PIVA et al. [8] & ZHANG et al. [16] through testing 50 images. Further, table 1 represents accuracy of proposed method to detect double compressed images and double cropped images. In Table1 variables A1 and A2 shows that PIVA et al. [8] and ZHANG et al. [16] accuracy detection. A3, A4 represent accuracy proposing algorithm for double jpeg detection without crop, double jpeg detection with crops images.

## 4. Conclusion

Nowadays, passive image forensic is great challenge in all of techniques. We have proposed new optimization technique for detecting all jpeg images has been double compressed, double compressed with crop and double compressed with tampered. The efficiency, sensitivity and robustness is validated by experiment as shown in table 1. In this paper, we focused on jpeg block artifact grid and future extraction by image block artifact. Our future works include detecting a tampered region when image is double compressed.

Table 1: Accuracy of detection of double compressed images in various methods

| *Quality Factor One* / *Quality Factor Two* | | **50** | **60** | **70** | **80** | **90** |
|---|---|---|---|---|---|---|
| **50** | A1 [8] | 78.1 | 62.3 | 20.3 | 1.5 | 1.3 |
| | A2 [16] | 76.0 | 70.8 | 65.7 | 59.6 | 53.6 |
| | A3 | 100 | 100 | 100 | 100 | 100 |
| | A4 | 100 | 100 | 100 | 100 | 100 |
| **60** | A1 [8] | 76.9 | 72.6 | 55.9 | 7.9 | 1.3 |
| | A2 [16] | 82.0 | 76.9 | 70.3 | 63.4 | 56.3 |
| | A3 | 100 | 87.0 | 100 | 100 | 100 |
| | A4 | 100 | 100 | 100 | 100 | 100 |
| **70** | A1 [8] | 88.6 | 90.5 | 86.0 | 34.7 | 0.8 |
| | A2 [16] | 89.0 | 83.4 | 76.6 | 68.0 | 58.9 |
| | A3 | 100 | 100 | 90.3 | 96.7 | 96.7 |
| | A4 | 100 | 100 | 100 | 100 | 100 |
| **80** | A1 [8] | 90.4 | 93.8 | 94.4 | 82.3 | 9.9 |
| | A2 [16] | 96.4 | 92.8 | 86.5 | 75.9 | 66.5 |
| | A3 | 100 | 96.7 | 96.7 | 96.7 | 83.5 |
| | A4 | 100 | 100 | 100 | 100 | 100 |
| **90** | A1 [8] | 92.4 | 95.5 | 97.1 | 98.1 | 71.7 |
| | A2 [16] | 99.0 | 98.9 | 97.8 | 93.9 | 74.7 |
| | A3 | 100 | 100 | 100 | 100 | 100 |
| | A4 | 100 | 100 | 100 | 100 | 100 |

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