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Trace Disclosure Analysis Using Quantization Noise Scheme in High-Quality JPEG Compression

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***Abstract*— Nowadays, a huge number of images are available to find the image tampering in a forensic environment. Due to its low-cost nature, the image acquisition and dissemination of digital images makes a great demand in conveying the information. To detect whether an image is JPEG compressed or not in forensic environment is an important issue. The natures of transform coding is lossy that makes the JPEG system to analysis on its traces of the images. Existing method fails on high-quality compressed image such as those with a quantization table containing mostly quantization steps being ones. The earlier technique doesn't deal on the high-quality JPEG compressed images. In this paper, we focused on high-quality JPEG compressed images. We introduced a novel scheme known as, Forward Quantization Noise (FQN) which investigated on the Trace Disclosure Analysis (TDA) of the compressed images. This scheme worked on the analysis of noises in images over multiple passes. We derived that the decompressed image exhibits lower variance than the uncompressed image. We introduced a detection algorithm that detects the high-quality decompressed images. From various sources of images, we experimented that our scheme outperforms better than the previous schemes in terms of robustness and chroma subsampling. Our proposed detection algorithm can efficiently execute in real-time applications such as Internet Image Classification, fraud detection, etc.**

***Index Terms*—JPEG Compression, Forward Quantization noise (FQN), Fraud Detection.**

I. INTRODUCTION

There are several types image compression standards exists, including lossy and lossless .These are exist because several kinds of requirements needed on image quality, storage, and transmission. In these, JPEG is a popular lossy compression standard .The main interest of image forensic experts on JPEG compressed images from unknown sources because to detect the image forgeries [2], [3] and processing history of images. There are some reported results on identifying whether an image is compressed [4],[5], or uncompressed , whether compressed an image twice or thrice [6]-[10] with shifted grid position

[11]- [13], and on estimating the JPEG quantization steps [5] and quantization table [14], [15]-[17].

In this paper, we concentrate on whether an image is truly in uncompressed form or has been previously JPEG compressed. Finding such historical records may help to answer forensics related questions i.e., where the image coming from, whether it is true image or forgery image. This solution may help to detect image forgeries created by replacing some part of image with another part of image with different compression historical records. The mismatch of historical records identify image forgeries. This JPEG identification problem [3], [4] may also estimate JPEG quantization steps. So, the forensic experts save time filtering out uncompressed images and performing estimate only on decompressed images [17]-[19].
High quality compressed images similar to uncompressed images due to their nearly lossless nature. So, this high quality compressed images used with uncompressed images for creating forgeries. Current forgery detectors [4], [5] are not capable are not detect high quality compressed images even in the anti-forensics detectors. So, this is the main problem to identify high quality compressed images when they decompressed and saved in uncompressed form.

Traces of JPEG compression might be found in image intensity domain. If we quantize high frequency discrete cosine transform coefficients with large quantization steps produces ringing effects when we saved in decompressed from. It produces blocky artifacts [20], [21] in case of heavy compression. In existing method Fan et al [4] describers an image is JPEG compressed based on pixel differences within the 8×8 blocks is similar to those across the blocks. This method is effective in detecting heavy compression of blocky artifacts. In case of an image is small size and high quality compression this method is not reliable.

Traces of JPEG compression may also found in the histogram of DCT coefficients. Luo et al [5] noted that JPEG compression reduces amount of DCT coefficients within the range of [-1, 1]. After an image is JPEG compressed the DCT coefficients within the range of [-1, 1] is small. The amount of DCT coefficients in the range of [-2, 2] is also found .When the statistics of a test image exceeds the threshold then it is classified as uncompressed image otherwise classified as previously JPEG compressed image .This method as few drawbacks. The first one is, it uses DCT coefficients that close to 0 .So, the information it not fully utilized. The second one is, it use quantization steps above 2 .So, this method fails to detect high quality compressed images because it contains quantization steps around one.

During this paper, we define a noise called as forward quantization noise .We develop simple algorithm to detect whether an image is JPEG compressed based on the variance of forward quantization noise. This method fully utilizes noise information on DCT coefficients. So it is neither limited to an image is large size nor quantization step being under to 2.Finally we show that our method is good compare to previous methods. This paper organized as follows. Section II describes theoretical work on multi-cycle JPEG compression .From this we show that how the variance is employed on forward quantization noise to detect JPEG compressed images on section III. In section IV describes results. The paper is concluded in section V.

II. JPEG QUANTIZATION NOISE ANALYSIS

A JPEG compression cycle [22], [23] consists of encoding phase and decoding phase. In encoding phase the data loss occurs due to quantization of DCT coefficients. The decoding phase is reverse of encoding phase. The truncation and integer rounding operation occurs when JPEG coefficients are restored in image intensity domain. In recent study [22], we represent a work for analyzing multi-cycle JPEG compression based on complete JPEG compression model compare with simplify model [5],[23]. This study focused on information losses in JPEG compression .Which are quantization noise and rounding noise. The truncation error is ignored because it is less impact on this model. Distribution of two noises derived. In this section, we summarize some results from the work and introduce some conventional notion.

A. Notations

In this total paper the noises introduced during JPEG compression are in lower case symbols and DCT coefficients in upper case symbols. The DCT coefficients in 8×8 gird numbered from 1 to 64. The first coefficient (u=1) is a DC coefficient due to low-pass property and it is a mean of all pixel values in an 8×8 block. Remaining coefficients (u=2… 64) are called as AC Coefficients due to high-pass. The index u is also used to indicate corresponding noise in DCT domain. The index m is used to indicate pixels in spatial domain and their noise indexed from 1 to 64.

The processing diagram for multi-cycle JPEG compression is shown in the left part of Fig. 1. $X^{(k)}$ and $\tilde{X}^{(k)}$ are used to denote floating point image in JPEG encoding and decoding phase respectively in k-th JPEG compression cycle. $Y^{(k)}$ and $\hat{Y}^{(k)}$ are used to describe un-quantized DCT coefficients in encoding phase and de-quantized coefficient in decoding phase. $I^{(k)}$ and $\tilde{I}^{(k)}$ are used to represent image integer representation. NIL means no processing step. $W^{(k)}$ is used to represent quantized DCT coefficients. The logical diagram for multi-cycle JPEG compression is shown in the right side of Fig. 1, obtained by dropping the NIL operation. In logical diagram rounding noise denoted by $x^{(k\to k+1)}$ and $y^{(k)}$ denotes quantization noise and also we define another two auxiliary noise $x^{(k)}$ in spatial domain, $y^{(k\to k+1)}$ in DCT domain.

B. Quantization Noise

The quantization noise is defined as the information loss due to JPEG quantization process i.e.,

$$y = Y - \hat{Y} = Y - \left[\frac{Y}{q}\right] q, q \in \mathbb{N} \qquad (1)$$

Where q is quantization step and [.] represents integer rounding operation

C. General Quantization Noise Distribution

In general, the distribution for quantization noise is given as

$$f_y(s) = \sum_{k=-\infty}^{\infty} f_Y(kq + s), \quad s \in \left[-\frac{q}{2}, \frac{q}{2}\right), k \in \mathbb{Z}, \qquad (2)$$

Where q is quantization step, f_Y and f_y is respectively distribution for Y and y respectively.

D. Specific Quantization Noise Distribution

In previous work we found that quantization noise of first round compression cycle is different from second round compression cycle

The distribution for quantization noise for first round cycle is given as

$$y_u^{(1)} \sim \begin{cases} U\left(-\frac{q_1^{(1)}}{2}, \frac{q_1^{(1)}}{2}\right), & u = 1 \\ Q^L\left(\lambda_{y_u^{(1)}}, q_u^{(1)}\right), & u \in \{2, 3, \ldots\ldots\ldots 64\}, \end{cases} \qquad (3)$$

Where U represents uniform distribution and Q^L represents quantized-Laplacian distribution. $q_u^{(1)}$ is the quantization step of the u -th frequency in the first compression cycle.

For all DCT coefficients of u, the second-cycle quantization noise distribution is

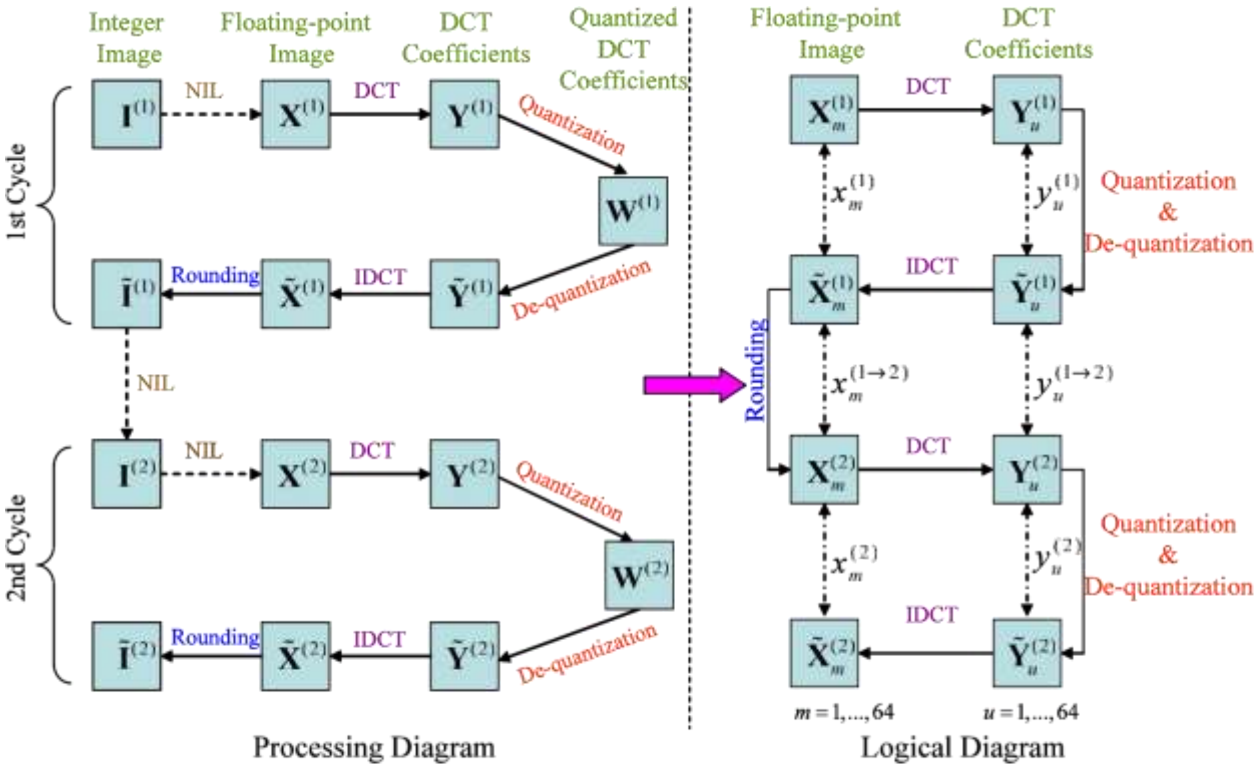

Fig 1.Processing steps for multi-cycle JPEG compression

$$y_u^{(2)} \sim \begin{cases} Q^N\left(\sigma^2_{y_u^{(1\to2)}},1\right), q_u^{(2)} = 1 \\ N\left(0,\sigma^2_{y_u^{(1\to2)}}\right), \quad q_u^{(2)} \geq 2 \text{ and } \left(\frac{q_u^{(1)}}{q_u^{(2)}}\right) \in \mathbb{N} \\ f_y \text{ as in Equation (2)}, \quad \text{otherwise} \end{cases} \qquad (4)$$

Where Q^N is quantized-Gaussian distribution. The distribution of $y_u^{(2)}$ may depend on the variance of the auxiliary noise $y_u^{(1\to2)}$.

III. IDENTIFICATION OF DECOMPRESSED JPEG IMAGES BASED ON QUANTIZATION NOISE ANALYSIS

In the following section we discuss forward quantization noise, and gives it relation to the quantization noise. Then we give upper bound for noise variance of uncompressed and compressed images. Finally, we give simple algorithm to differentiate decompressed images from uncompressed images.

A. Forward Quantization Noise

If we give an uncompressed image in JPEG encoding phase, we can get quantization noise of that cycle. Suppose if we give a compressed image, but stored in uncompressed we did not quantization noise of that cycle, but we can find quantization noise of next cycle .So, finally we say that quantization noise

available for current available cycle as forward quantization noise. Quantization noise is function of quantization step. From this work the simplest form of quantization noise with quantization step 1 i.e.

$$z = Y - [Y], \qquad (5)$$

Where Y is DCT coefficient

For an uncompressed image the forward quantization noise is first compression cycle quantization noise with quantization step one, i.e., $q_u^{(1)} = 1$, $u \in (1,2,\ldots\ldots.64)$.For a compressed image the forward quantization noise is second cycle quantization noise with $q_u^{(2)} = 1$, $u \in (1,2,\ldots\ldots.64)$.

B. Noise variance for compressed images

The upper bound for the variance of forward quantization noise of an uncompressed image:

$$\sigma_z^2 = \sigma_{y^{(2)}}^2 \leq C_0 \quad (6)$$
$$where\ C_0 = 0.0833$$

C. Noise Variance for Images With Prior JPEG Compression

The upper bound for the variance of forward quantization noise of an image with prior JPEG compression:

$$\sigma_z^{(2)} = \sigma_{y^{(2)}}^2 \leq \begin{cases} C_2, if\ q_u^{(1)} = 1, \forall u, \\ C_1, \quad otherwise \end{cases} \quad (7)$$

By combining (6) and (7) we have get following result for forward quantization noise. Given a test image I, the variance of forward quantization noise z with q=1 is given by

$$\sigma_z^{(2)} \leq \begin{cases} C_0, & if\ I\ is\ uncompressed, \\ C_1, & if\ I\ was\ compressed\ once. \end{cases} \quad (8)$$

Where C_0=0.0833, C_1=0.0638, C_2=0.0548

D. Identification of Decompressed JPEG Images

The above result on noise variance is derived theoretically. The distribution of practical samples may vary from theoretical result because of finite sample size. The variance of the practical samples is denoted by $\tilde{\sigma}_z^{(2)}$, may slightly exceeds upper bound, i.e., C_1 or C_0

$$I = \begin{cases} uncompressed, & \tilde{\sigma}_z^{(2)} > T, \\ decompressed, & \tilde{\sigma}_z^{(2)} \leq T, \end{cases} \quad (9)$$

Where T is a predefined threshold which is in between C_1 and C_0

IV. EXPERMENTEL RESULTS.

To evaluate the results 256×256 images are used .First we take an image and then it compressed with quality factor 95.Fig 2 gives JPEG compressed and decompressed image. In this results only evaluated parameter is variance. The variance shown in fig 4. For an uncompressed image the variance is below 0.0833. If an image is compressed the variance is below 0.0638 is shown in fig 4. An example for tampering is shown in fig 3.

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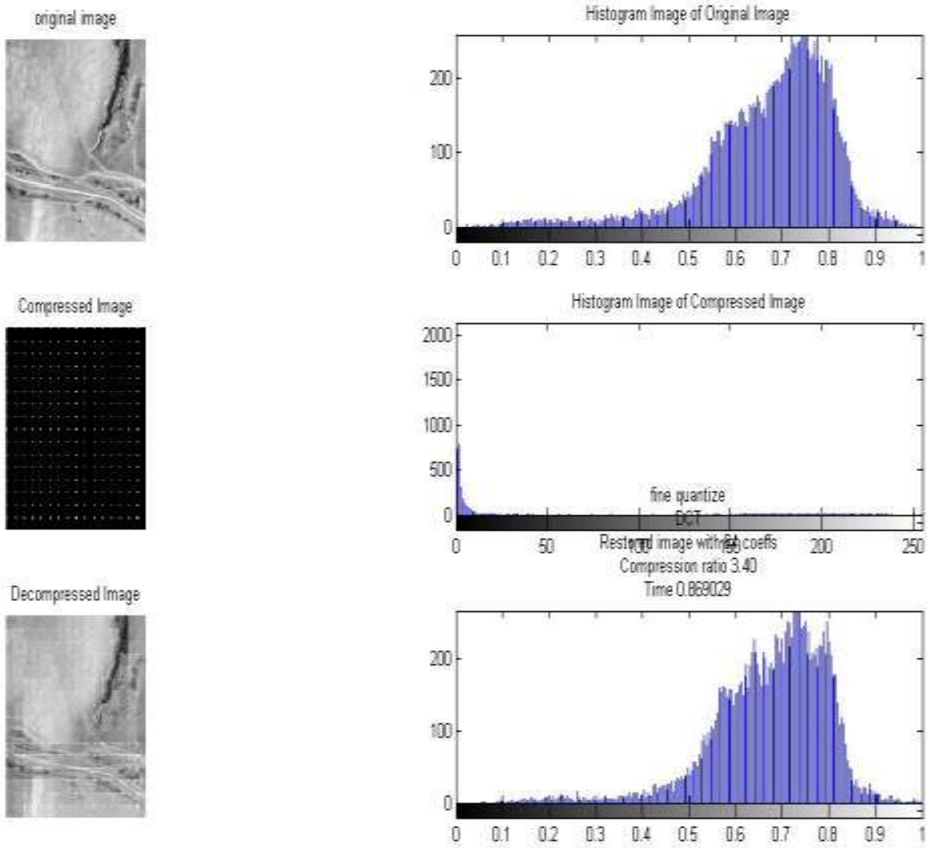

Fig 2. JPEG uncompressed and decompressed image

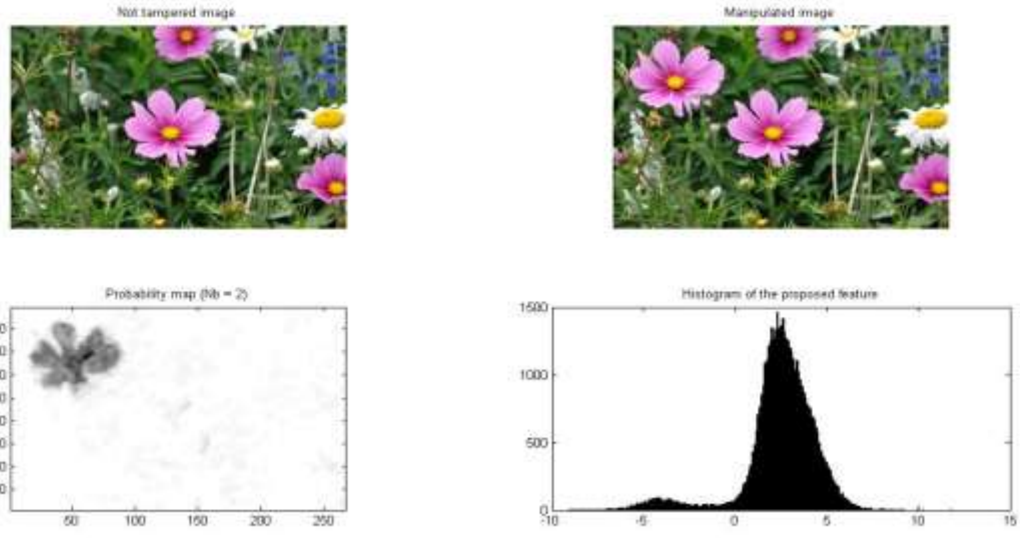

Fig 3. An example for tampering.

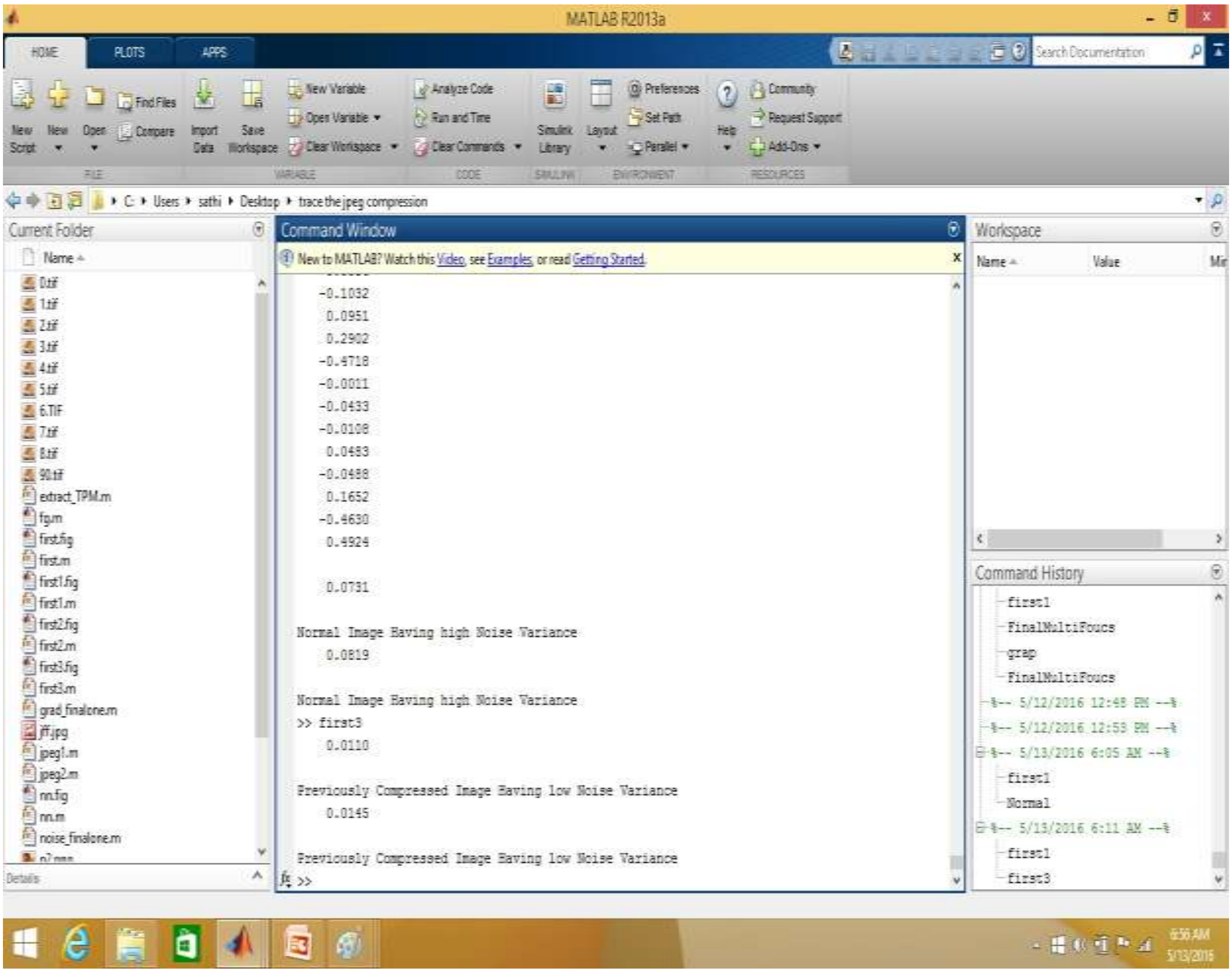

Fig 4. Comparing noise variance.

V. CONCLUSION AND FUTURE SCOPE

In this paper, we propose a method to reveal the traces of JPEG compression. The proposed method based on the variance of forward quantization noise. We derived decompressed JPEG image is lower noise variance than the uncompressed image. We applied this method challenges posed by high quality JPEG compression identification. The proposed can be applied to forgery detection. Our future studies will be on trying to extend the noise analysis to other forensic task, i.e., identifying the resized decompressed JPEG images such as images presented in IEEE IFS.

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