Detection of Double JPEG Compression on Color Image using Neural Network Classifier

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Abstract

Identification of double JPEG compression with same quantization lattice is a testing issue. Recognition of double JPEG compression assumes an essential part in computerized picture legal sciences. Some effective approaches have been proposed to identify double JPEG compression when primary and secondary compression have diverse quantization matrix. Nonetheless, distinguishing double JPEG compression with same quantization matrix is still a testing issue. Here, a powerful error based statistical feature extraction scheme is introduced to tackle this issue. Initial, a given JPEG file is decompressed to frame a reconstructed image. An error image is obtained by processing the contrasts between the inverse discrete cosine transform coefficients and pixel values in the reconstructed image. Two classes of blocks in the error image, in particular, rounding error block and truncation error block, are analyzed. Then a group of features are proposed to differentiate between single and double JPEG images. At last artificial neural network classifier is used to identify whether a given JPEG image is double compressed or not. The process is implemented in a MATLAB 2014.

Keywords: Computerized Picture, Legal Sciences, Rounding Error, Truncation Error

I. INTRODUCTION

These days JPEG forensic issues have been receiving more consideration as of late. The Joint Photographic Experts Group stands for JPEG as standards committee that had its origin within the International Standard Organization (ISO). Double JPEG compression we understand the repeated compression of the image with different quantization matrices primary quantization matrix and secondary quantization matrix. Here we detecting double JPEG compression with the same quantization matrix is still a challenging problem. We propose an effective method that utilizes error based statistical feature (EBSF). Firstly, an error image is formed by computing the difference between the inverse DCT (IDCT) coefficients and pixel values during JPEG decompression. Two classes of error blocks in the error image are definitive, rounding and truncation error blocks. Subsequently, statistical difference of the rounding and truncation error blocks between single and double JPEG compression are characterized by three subset of features in both spatial and DCT domain. Finally, under the machine learning framework, the extracted features are combined to detect double JPEG compression with the same quantization matrix.

Digital images are used as photographic evidence by the government agencies, legal authorities, media organization and by many others. The image can undergo various kind of forgeries like copy-paste, cut-paste etc. For example, in image splicing, one part of the source image is copied to the target image to generate a new composite image. If the source image or target image is in the JPEG format, the spliced image may need to be JPEG compressed, hence exhibiting traces of double JPEG compression. These trace can be used to detect the forgery image or even identify the manipulated areas.

The two common approaches for image authentication and tamper detection are classified as Active and Passive approach. The active approach uses intrusive techniques like Digital Watermarks and Digital Signature. Digital Watermarking embeds a message at the source side that as a watermark which can be extracted later on to verify the authenticity of an image. Digital Watermarks mostly are inseparable from digital image they are embedded in and undergo the same transformations as the image itself resulting in depreciation in quality. Therefore, any manipulation before the watermark was embedded cannot be detected using this method. Watermarking system was not applicable on images or videos from surveillance cameras, military cameras etc. Passive techniques popularly known as Blind method.

There are two reasons why forensic experts pay attention to the detection of double JPEG compression. The first one is that the doubly compressed JPEG images often result from image forgery. Some JPEG steganography schemes such as F5 ND out-guess may generate doubly compressed images if input cover image is in JPEG format. JPEG is a loss compression method. It employs a transform coding method using the DCT. According to the study first the image is divided into 8*8 blocks then apply DCT on the image blocks to obtain DCT values then quantize using quantization matrix and entropy encoding of the quantized DCT coefficients. JPEG decompression is performed in the reverse order: entropy decoding, dequantization and inverse DCT. There exist three kinds of error during JPEG compression and decompression. The first kind of error is called quantization error which occurs in the process of JPEG compression. Both second and third kinds of error exists in the process of JPEG decompression that is rounding and truncation error. Only rounding and truncation error can be utilized to discriminate between singly and double
compression image with the same quantization matrix. Then error based statistical features are extracted from rounding and truncation error blocks separately for detecting double JPEG compression with same quantization matrix.

II. RELATED WORKS

There are many methods to detect the double JPEG compression. In [2] Yun Q. Shi proposes a novel statistical model based on Benfords law to fit distribution of the first digits of JPEG coefficients from some selected individual ac modes, the performance of detecting double JPEG compression could be greatly enhanced. Combined with a multiclass classification strategy the quality factor QF in the primary JPEG compression can be identified. The problem with this method is that it is not suitable for color images. In [3] Thomas Pevny and Fridrich introduced a method for detection of double compression in JPEG for application in steganography that is based on DCT coefficients. First a reliable method for the detection of double compression JPEG image is presented. It is based on classification using SVM with features derived from the first-order statistics of individual DCT modes of low-frequency DCT coefficients. ML estimator of the primary quality factor in double compressed JPEG image is build. Since the main application is steganalysis the estimator was constructed to work for cover and stegoimages. The problem with this method is that steganography system are weak to withstand various attacks.

In [4] Jan Lukas and Jessica proposes a method for estimation of primary quantization matrix from double compressed JPEG image. They focused on the estimation of the primary quantization steps for low frequency DCT coefficients because the estimates for higher frequency become progressively less reliable due to insufficient statistics. In this first identify characteristic feature that occur in DCT histograms of individual coefficients due to double compression. Then three different approaches that estimate the orginal quantization matrix from double compressed images. Two of them were based on matching the histogram of individual DCT coefficients of the inspected image with the histograms calculated from estimates obtained by calibration followed by simulated double compression. Both histogram matching approaches were outperformed by the third methods that used a collection of neural network. The problem with this method is that some combination of quantization step are indistinguishable from single JPEG compression. In [5] Fausto Galvan proposed a novel algorithm for the estimation of the first quantization steps from double compressed JPEG images. The approach combine a filtering strategy and an error function with good localization property obtains statisfactory results outperforming the other state-of-the-art approaches both for low and high frequencies. This method will not work for any other histogram.

In [6] Zhigang Fan provided a fast and efficient method to determine whether an image has been previously JPEG compressed. This paper only deals with JPEG compression of monochrome images, hence the only useful compression parameter that effects the image quality is the quantizer table. A method for the maximum likelihood estimation (MLE) of JPEG quantization tables is presented where the only information available is a bitmap of the decoded image. The method is used in conjunction with a very simple and efficient method to identify if an image has been previously JPEG compressed. The problem with this method is that it is not applicable in color images. In [7] Weiqi Luo proposed a method for JPEG error analysis to the study of image forensics. Then various errors of JPEG image compression and their relationship in double compression is analyzed. The method used for detection is based on the range of AC coefficient. This technique is used for small image and this method is more reliable. The problem with this method is that it is sensitive to image size.

In [8] Z Lina proposed an algorithm for tampered JPEG image detection by analyzing the DQ effects hidden among the histograms of the DCT coefficients. This method is based on DQ effect. This method have several advantages like it is capable of locating the tampered region automatically without the user to prescribe the suspicious region the detection is at a fine grained scale detecting tampered images synthesized by the cut/paste skill interpolation or resampling may precede. This method also have disadvantages like if orginal image which contributes to the unchanged region is not a JPEG image. In [9] Chunhua Chen propose a novel and effective scheme based on machine learning framework to identify double JPEG compressed image in this paper. Features are formulated from the JPEG coefficient 2-D array of a given JPEG image. Markov random process is applied to model to model these arrays. The problem with this is that the double JPEG compression artifacts disturb the difference 2-D array weakening the correlation among elements of the difference 2-D array of a double JPEG compressed image.

In [10] Zhigang Fan propose a method that aims to estimate the JPEG CH from a given JPEG decompressed color image.This problem is refer to as JPEG Compression History Estimation (CHEst).Method used is CHEst algorithm .The main advantage is file size reduction without introducing additional distortion and it could contribute to applications such as covert message passing and image image authentication. The problem with this method is that it is complex since it have to be applied to each RGB component seperatly. In [11] Fangjun Huang proposed a method to detect double JPEG compression with the same quantization matrix. The main advantage is that this method can be used to detect triple JPEG compression and four times JPEG compression. This method is is not suitable if the selected portion is too big or too small.

III. PROPOSED METHODOLOGY

The main objective of this method is to detect double compression using same quantization matrix. First the image is compressed it involve three steps, each image is divided into 8*8 block then Discrete cosine transform is applied to each block these values are then quantized using standard quantization matrix and entropy encoded. JPEG decompression is performed in the reverse order: entropy decoding, de-quantization and inverse DCT. There are mainly three kinds of error during JPEG compression and decompression. First is quantization error which occur during JPEG compression process. It is defined as the difference between
the float value of divided DCT coefficient before rounding and its nearest integer value. Both the second and third kind of error exist in the process of JPEG decompression. After performing IDCT on dequantized JPEG coefficients float values should be truncated and rounded to nearest integer value. Rounding error is defined as difference between the float IDCT coefficient and its rounded integer. While the difference between the float IDCT coefficient and its truncated integer is called the truncation error.

Rounding error and truncation error are considered for the detection of image compression. During calculation it is found that rounding error blocks have all the values falls in the range of [-0.5,0.5]. While a truncation error block is a block of which at least one element exceeds the range [-0.5,0.5].

\[ E_n = RT \left( \text{IDCT} \left( D_q \right) \right) - \text{IDCT} \left( D_n \right) \]  

(1)

Where RT is rounding error and truncation error operation in JPEG decompression. IDCT denotes the inverse discrete cosine transform on all the blocks, \( D_q \) represent the dequantized value within the image.

\[ D_q = L \times Q \]  

(2)

Where Q is the quantization matrix and Ln denotes the JPEG coefficient matrix* is the component wise multiplication on each pixel. After compression there are certain block values that does not varies and such blocks can be called as stable blocks and can be denoted by \( M_n \), other block whose value \( M_n \neq 0 \) is called unstable blocks. While analysing the error blocks for the detection of double compression these stable blocks will not provide any useful information so it is eliminated before computation. As number of compression increases unstable error blocks reduces and stable error blocks values remains the same.

**B. Stable Blocks and Unstable Blocks**

In the proposed system the jpeg image are compressed using the same quantization matrix. Error blocks in an error image of an n-times compressed JPEG image is denoted by \( E_n \).

**C. Feature Extraction from Images**

The images are taken from the database which consist of uncompressed images. To identify the characteristics of rounding and truncation error, the statistical difference between single and double compressed images are taken. The error-based statistical features are extracted separately from rounding and truncation error block. The error based statistical feature consist of three subset. The first subset of features are extracted directly from the error image which is denoted by \( EBSF_{spatial} \). It contain the mean and variances of absolute error values over the rounding and truncation error blocks. The mean and variance of absolute error values for the rounding error blocks denoted by mean \( \| R_r \| \) and var \( \| R_r \| \) are given by

\[ \text{mean} \| R_r \| = \frac{1}{64L} \sum_{L \times L} \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} R_{r} \left( i, j \right) \]  

(3)
\[
\text{var}[R_i] = \frac{\sum_{i=1}^{L} \sum_{j=1}^{L} (R_{n}^{\text{e}}(i, j))}{64L}
\]

(4)

Where \( L \) denotes the number of the unstable rounding error blocks in the error image. The mean and variance of absolute error values for the truncation error block are denoted by \( \text{mean}[R_i] \) and \( \text{var}[R_i] \) can also be calculated in a similar way.

EBSF_{dct} is the second subset of features extracted, which consist of mean and variance of absolute values of \( W_n \) over rounding and truncation error block. The DCT coefficient of the DC and AC components exhibit different characteristic, thus features from the DC and AC components of \( W_n \) should be extracted separately. For the rounding error blocks, the mean and variance of absolute values of DC component of \( W_n \) denoted by \( \text{mean}[W_{1d}] \) and \( \text{var}[W_{1d}] \) can be given by

\[
\text{mean}[W_{1d}] = \frac{\sum_{i=1}^{L} \sum_{j=1}^{L} |W_{1d}(0,0)|}{L}
\]

(5)

\[
\text{var}[W_{1d}] = \frac{\sum_{i=1}^{L} \sum_{j=1}^{L} |W_{1d}(0,0)|^2 - \text{mean}[W_{1d}]^2}{L}
\]

(6)

Where \( W_{1d}(0,0) \) denotes the DC component of \( W_n \) from the 1\textsuperscript{st} rounding error block. The mean and variance of absolute values of the AC component of \( W_n \), denoted by \( \text{mean}[W_{1v}] \) and \( \text{var}[W_{1v}] \) are

\[
\text{mean}[W_{1v}] = \frac{\sum_{i=1}^{L} \sum_{j=1}^{L} |W_{1v}(u,v)|}{L}
\]

(7)

\[
\text{var}[W_{1v}] = \frac{\sum_{i=1}^{L} \sum_{j=1}^{L} |W_{1v}(u,v)|^2 - \text{mean}[W_{1v}]^2}{L}
\]

(8)

Where \( W_{1v}(u,v) \) denotes the \((u,v)\)th AC component of \( W_n \) from the 1\textsuperscript{st} rounding error block. For the truncation error blocks, the statistical values of the DC and AC components of \( W_n \), including \( \text{mean}[W_{2d}] \) \( \text{var}[W_{2d}] \) \( \text{mean}[W_{2v}] \) and \( \text{var}[W_{2v}] \) also be calculated in a similar way.

The third set of features EBSF_{ratio} which will contain only one feature. It is the ratio of the number of unstable rounding error blocks, \( n_e \), to the number of all unstable error blocks, \( n_e \). There are so thirteen features all together from EBSF_{spatial}, eight feature from EBSF_{dct} and one from EBSF_{ratio} are provided as an input to the ANN to detect whether the given image is single or double compressed.

Neural Network Toolbox provides algorithms, functions, and apps to create, train, visualize and simulate neural networks. It can perform classification, regression, clustering, dimensionality reduction, time-series forecasting and dynamic system modelling and control. The toolbox includes convolutional neural network and auto encoder deep learning algorithms for image classification and feature learning tasks. To speed up training of large data sets, this can distribute computations and data across multicore processors, GPUs, and computer clusters using Parallel Computing Toolbox.

Training and learning functions are mathematical procedures used to automatically adjust the network’s weights and biases. The training function dictates a global algorithm that affects all the weights and biases of a given network. The learning function can be applied to individual weights and biases within a network. Neural Network Toolbox supports a variety of training algorithm, including several gradient descent method, conjugate gradient methods, the Levenberg-Marquardt algorithm and the resilient backpropagation algorithm. The toolboxes modular framework lets us quickly develop custom training algorithms that can be integrated with built-in algorithm. While training this neural network, this can use error weights to define the relative importance of desired outputs, which can be prioritized in terms of sample, time step, output element or any combination of these. This can access training algorithms from the command line or via apps that shows diagrams of the network being trained and provide network performance plots and status information to help you monitor the training process.

IV. EXPERIMENTAL RESULTS

The method was implemented in a MATLAB 2014 prototype and tested with raw image collected from the database. Both the image were compressed and test were performed on a desktop PC with the following characteristics: Intel Core i3 CPU, 3.4 GHz, 4 GB RAM.

The database was build with raw images. A camera raw image file contains minimally processed data from the image sensor of either a digital camera, image scanner, or motion picture film scanner. Raw images were usually stored in tif format. Usually the size of the raw images are very much larger when compared to image that are stored in JPEG format. In this process the image is not converted to gray scale images and each component in the color image is multiplied with same standard JPEG quantization.
matrix. The database is built. Then SVM training and ANN is executed. Then test is performed to detect whether an image can be double compressed with same quantization matrix.

Detecting double JPEG compression is performed using same quantization matrix.

\[
Q = \begin{bmatrix}
16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\
12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\
14 & 13 & 16 & 24 & 40 & 57 & 69 & 56 \\
14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\
18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\
24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\
49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\
72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \\
\end{bmatrix}
\]

Fig. 4: Standard quantization matrix

To check the performance of the proposed system we change the quality factors. A set of features in JPEG image are given to ANN classifier. The error-based statistical feature (EBSF) are extracted from rounding and truncation error blocks separately for detecting double JPEG compression with same quantization matrix. The EBSF feature set consists of three subset: EBSF_{spatial} which is extracted directly from error images, EBSF_{dct} and third set of feature EBSF_{ratio} which will contain only one feature. All the feature are extracted and the images are tested, both SVM and ANN classifiers are used to test the accuracy and performance when quality factors are changed.

The number of rounding and truncation error block in each image is calculated. The rounding error blocks are those blocks who’s value falls in the range of \([-0.5,0.5]\) and truncation error block are blocks having values such that at least one value of the coefficients in the block exceeds the limit of \([-0.5,0.5]\).

By changing the quality factors the test is performed in both SVM and ANN classifier and better accuracy was shown in ANN classifier.
Detection of Double JPEG Compression on Color Image using Neural Network Classifier

In this paper a novel method is present to detect double JPEG compression with same quantization matrix, which is easy to implement while shows performance. There are two type of blocks in JPEG compression, that is stable error block and unstable error blocks. Unstable error blocks of compressed image can provide discriminative information for distinguishing itself from its recompressed version. The error blocks are categorized into rounding error block and truncation error block. Error based statistical feature were extracted from error blocks separately, then features are obtained by various calculation. Finally, with the extracted features, ANN is applied for detecting double JPEG compression.

The advantage of the proposed method is that it can effectively characterize the magnitude information of rounding and truncation error, instead and also the proposed features are directly extracted from spatial and DCT domain of the error image.

V. CONCLUSION

In this paper a novel method is present to detect double JPEG compression with same quantization matrix, which is easy to implement while shows performance. There are two type of blocks in JPEG compression, that is stable error block and unstable error blocks. Unstable error blocks of compressed image can provide discriminative information for distinguishing itself from its recompressed version. The error blocks are categorized into rounding error block and truncation error block. Error based statistical feature were extracted from error blocks separately, then features are obtained by various calculation. Finally, with the extracted features, ANN is applied for detecting double JPEG compression.

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REFERENCES


