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A Review: Singly and Doubly Jpeg Compression In The Presence of Image Resizing

Veerpal Kaur¹

Student,
Guru Kashi University,
Talwandi Sabo
Bathinda – India

Monica Goyal²

Assistant Professor,
Guru Kashi University,
Talwandi Sabo
Bathinda – India

Abstract: In this work, we propose a forensic technique for the reverse engineering of double JPEG compression in the presence of image resizing between the two compressions. Our approach aims at exploiting the fact that previously JPEG compressed images tend to be distributed near the points of a lattice and is based on the extension of the technique proposed in [6] for nonaligned double JPEG compression. The proposed technique moves a step further, since it also provides an estimation of both the resize factor and the compression parameters of the previous JPEG compression. Such additional information is important, since it can be used to reconstruct the history of an image and Performa more detailed forensic analysis. One of the major difficulties encountered in image processing is the huge amount of data used to store an image. Thus, there is pressing need to limit the resulting data volume. It is necessary to find the statistical properties of the image to design an appropriate compression transformation of the image; the more correlated the image data are, the more data items can be removed. A wavelet transform combines both low pass and high pass filtering in spectral decomposition of signals so it becomes more complex and take more time. Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, maps and logos, where the loss of information is not acceptable. As our main objective is to work with a different interpolation algorithm for image compression. With various parameters such as minimum entropy, Q-factor, quality factor etc. for compressing the color images without losing any contents of the images and to maintain the storage memory space.

Keywords: JPEG Compression, Spectral decomposition, minimum entropy, Q-factor, Interpolation.

I. INTRODUCTION

1. JPEG COMPRESSION

JPEG compression is defined as a lossy coding system which is based on the discrete cosine transform. However, there are several extensions to the JPEG algorithm to provide greater compression, higher precision, and can be tailored to specific applications. [3] It can also be used as a lossless coding system that may be necessary for applications requiring precise image restoration. JPEG has four defined extension modes: sequential DCT based, progressive DCT based, lossless, and hierarchical mode.

2. Basics of JPEG Compression

Typically, the image is first converted from RGB to YCbCr, consisting of one luminance component (Y), and two chrominance components (Cb and Cr). Mostly, the resolution of the chroma components is reduced, usually by a factor of two. Then, each component is split into adjacent blocks of 8×8 pixels. Blocks values are shifted from unsigned to signed integers. Each block of each of the Y, Cb, and Cr components undergoes a discrete cosine transform (DCT). Let $f(x, y)$ denotes an 8×8 block. Its DCT is:

$$F(u, v) = \frac{1}{4} C(u) C(v) \sum_{x=0}^7 \sum_{y=0}^7 \cos \frac{(2x+1)u\pi}{16} \cos \frac{(2y+1)v\pi}{16},$$

where

$$\begin{aligned} (u, v) &\in \{0 \dots 7\}; \\ C(u), C(v) &= 1/\sqrt{2} \quad \text{for } u, v = 0; \\ C(u), C(v) &= 1 \quad \text{otherwise.} \end{aligned}$$

In the next step, all 64 $F(u, v)$ coefficients are quantized. Then, the resulting data for all blocks is entropy compressed typically using a variant of Huffman encoding. The quantization step is performed in conjunction with a 64-element quantization matrix, $Q(u, v)$. Quantization is a many-to-one mapping. Thus it is a lossy operation. Quantization is defined as division of each DCT coefficient by its corresponding quantizer step size defined in the quantization matrix, followed by rounding to the nearest integer:

$$F^Q(u, v) = \text{round}\left(\frac{F(u, v)}{Q(u, v)}\right), \quad u, v \in \{0 \dots 7\}$$

Generally, the JPEG quantization matrix is designed by taking the visual response to luminance variations into account, as a small variation in intensity is more visible in low spatial frequency regions high spatial frequency regions. The JPEG decompression works in the opposite order, entropy decoding followed by de-quantization step and inverse discrete cosine transform.

3. Double JPEG Quantization and its Effect on DCT coefficients

By double JPEG compression we understand the repeated compression of the image with different quantization matrices Q_1 (primary quantization matrix) and Q_2 (secondary quantization matrix). The DCT coefficient $F(u, v)$ is said to be double quantized if $Q_2(u, v) \neq Q_1(u, v)$. The double quantization is given by:

$$F^{Q^\beta}(u, v) = \text{round}\left(\frac{F^{Q^\alpha}(u, v) Q^\alpha(u, v)}{Q^\beta(u, v)}\right)$$

Generally, the double quantization process brings detectable artifacts like periodic zeros and double peaks. The double quantization effect has been studied in [13, 3, and 6]. Therefore, for a more detailed analysis of double quantization effects.

II. RELATED WORK

B. Brindha, G. Raghuraman (2013), [1] In the paper, "Region Based Lossless Compression for Digital Images in Telemedicine Application" proposes a very efficient and low complexity compression method for Digital Imaging and Communications in Medicine (DICOM) images. Main advantages of Region based coding technique is exploited in their paper. ROI part of the image is identified by manually and combined with effect of Integer Wavelet Transform (IWT) which is useful to reconstruct the original image, reversibly with desired quality. The overall compression process helps to reach a satisfactory level for image transmission in limited bandwidth over a telemedicine application.

B. Li , Y. Shi and J. Huang (2008), [2] In this paper, we utilize the probabilities of the first digits of quantized DCT (discrete cosine transform) coefficients from individual AC (alternate current) modes to detect doubly compressed JPEG images. Our proposed features, named by mode based first digit features (MBFDF), have been shown to outperform all previous methods on discriminating doubly compressed JPEG images from singly compressed JPEG images. Furthermore, combining the MBFDF with a multi-class classification strategy can be exploited to identify the quality factor in the primary JPEG compression, thus successfully revealing the double JPEG compression history of a given JPEG image.

C. Chen, Y. Q. Shi, and W. Su,(2008) [3] In this paper, Double JPEG compression detection is of significance in digital forensics. We propose an effective machine learning based scheme to distinguish between double and single JPEG compressed images. Firstly, difference JPEG 2D arrays, i.e., the difference between the magnitude of JPEG coefficient 2D array of a given JPEG image and its shifted versions along various directions, are used to enhance double JPEG compression artifacts. Markov random process is then applied to modeling difference 2-D arrays so as to utilize the second-order statistics. In addition, a thresholding technique is used to reduce the size of the transition probability matrices, which characterize the Markov random processes. All elements of these matrices are collected as features for double JPEG compression detection. The support vector machine is employed as the classifier. Experiments have demonstrated that our proposed scheme has outperformed the prior arts.

Deepak.S.Thomas, M.Moorthi and R.Muthalagu,(2014), [4] The project proposes hybrid image compression model for efficient transmission of medical image using lossless and lossy coding for telemedicine application. Here, Fast- discrete curvelet transform with adaptive arithmetic coding will be used for loss less compression. Since storage space demands in hospitals are continually increasing the compression of the recorded medical images is the need of the hour. This would imply the need for a compression scheme that would give a very high compression ratio. Given a particular compression ratio, the quality of the image reconstructed using the AAC would be better. This project presents a method of employing both methods of compression in an intelligent manner to achieve better compression ratio and less error rate. This is also taken care of in the paper. And the regions of diagnostic importance are undisturbed in course of achieving energy efficiency. This method will be evaluated through parameters like mean square error, quality factor and compression ratio.

D. Fu, Y. Q. Shi, and W. Su. (2007) [5] In this paper, a novel statistical model based on Benford's law for the probability distributions of the first digits of the block-DCT and quantized JPEG coefficients is presented. A parametric logarithmic law, i.e., the generalized Benford's law, is formulated. Furthermore, some potential applications of this model in image forensics are discussed in this paper, which include the detection of JPEG compression for images in bitmap format, the estimation of JPEG compression Q factor for JPEG compressed bitmap image, and the detection of double compressed JPEG image. The results of our extensive experiments demonstrate the effectiveness of the proposed statistical model.

Farid, H., (2009), [6] When creating a digital forgery, it is often necessary to combine several images, for example, when compositing one person's head onto another person's body. If these images were originally of different JPEG compression quality, then the digital composite may contain a trace of the original compression qualities. To this end, we describe a technique to detect whether the part of an image was initially compressed at a lower quality than the rest of the image. This approach is applicable to images of high and low quality as well as resolution.

G. Wallace (1992), [7] In this paper, a joint ISO/CCITT committee known as JPEG (Joint Photographic Experts Group) has been working to establish the first international compression standard for continuous-tone still images, both grayscale and color. JPEG's proposed standard aims to be generic, to support a wide variety of applications for continuous-tone images. To meet the differing needs of many applications, the JPEG standard includes two basic compression methods, each with various modes of operation. A DCT (discrete cosine transform)-based method is specified for 'lossy' compression, and a predictive method for 'lossless' compression. JPEG features a simple lossy technique known as the Baseline method, a subset of the other DCT-based modes of operation. The Baseline method has been by far the most widely implemented JPEG method to date, and

is sufficient in its own right for a large number of applications. The author provides an overview of the JPEG standard, and focuses in detail on the Baseline method

H. Farid, (2009) [9] The author reviews the state of the art in this new and exciting field. We are undoubtedly living in an age where we are exposed to a remarkable array of visual imagery. While we may have historically had confidence in the integrity of this imagery, today's digital technology has begun to erode this trust. From the tabloid magazines to the fashion industry and in mainstream media outlets, scientific journals, political campaigns, courtrooms, and the photo hoaxes that land in our e-mail in-boxes, doctored photographs are appearing with a growing frequency and sophistication. Over the past five years, the field of digital forensics has emerged to help restore some trust to digital images.

Avcibas S. Bayram , N. Memon , B. Sankur and M. Ramkumar (2004), [10] In this paper we present a framework for digital image forensics. Based on the assumptions that some processing operations must be done on the image before it is doctored and an expected measurable distortion after processing an image, we design classifiers that discriminates between original and processed images. We propose a novel way of measuring the distortion between two images, one being the original and the other processed. The measurements are used as features in classifier design. Using these classifiers we test whether a suspicious part of a given image has been processed with a particular method or not. Experimental results show that with a high accuracy we are able to tell if some part of an image has undergone a particular or a combination of processing methods.

J. Fridrich and J. Lukas, (2003), [11] In this paper, we present a method for estimation of primary quantization matrix from a double compressed JPEG image. We first identify characteristic features that occur in DCT histograms of individual coefficients due to double compression. Then, we present 3 different approaches that estimate the original quantization matrix from double compressed images. Finally, most successful of them - Neural Network classifier is discussed and its performance and reliability is evaluated in a series of experiments on various databases of double compressed images. It is also explained in this paper, how double compression detection techniques and primary quantization matrix estimators can be used in steganalysis of JPEG files and in digital forensic analysis for detection of digital forgeries.

J. Fridrich and T. Pevny.(2008), [12] This paper presents a method for the detection of double JPEG compression and a maximum-likelihood estimator of the primary quality factor. These methods are essential for construction of accurate targeted and blind steganalysis methods for JPEG images. The proposed methods use support vector machine classifiers with feature vectors formed by histograms of low-frequency discrete cosine transformation coefficients. The performance of the algorithms is compared to selected prior art.

J. He, Z. Lin, L. Wang, and X. Tang(2006), [13] In this paper, the steady improvement in image/video editing techniques has enabled people to synthesize realistic images/videos conveniently. Some legal issues may occur when a doctored image cannot be distinguished from a real one by visual examination. Realizing that it might be impossible to develop a method that is universal for all kinds of images and JPEG is the most frequently used image format, we propose an approach that can detect doctored JPEG images and further locate the doctored parts, by examining the double quantization effect hidden among the DCT coefficients. Up to date, this approach is the only one that can locate the doctored part automatically. And it has several other advantages: the ability to detect images doctored by different kinds of synthesizing methods (such as alpha matting and inpainting, besides simple image cut/paste), the ability to work without fully decompressing the JPEG images, and the fast speed. Experiments show that our method is effective for JPEG images, especially when the compression quality is high.

S. Ye , Q. Sun and E. Chang (2007) , [14] In this paper, digital images can be forged easily with today's widely available image processing software. In this paper, we describe a passive approach to detect digital forgeries by checking inconsistencies of blocking artifact. Given a digital image, we find that the blocking artifacts introduced during JPEG compression could be used as a "natural authentication code". A blocking artifact measure is then proposed based on the estimated quantization table

using the power spectrum of the DCT coefficient histogram. Experimental results also demonstrate the validity of the proposed approach.

T. Bianchi and A. Piva,(2012), [15] In this paper, a simple yet reliable algorithm to detect the presence of nonaligned double JPEG compression (NA-JPEG) in compressed images is proposed. The method evaluates a single feature based on the integer periodicity of the blockwise discrete cosine transform (DCT) coefficients when the DCT is computed according to the grid of the previous JPEG compression. Even if the proposed feature is computed relying only on DC coefficient statistics, a simple threshold detector can classify NA-JPEG images with improved accuracy with respect to existing methods and on smaller image sizes, without resorting to a properly trained classifier. Moreover, the proposed scheme is able to accurately estimate the grid shift and the quantization step of the DC coefficient of the primary JPEG compression, allowing one to perform a more detailed analysis of possibly forged images

T. Bianchi (2012), [16] In this paper, we propose a forensic technique for the reverse engineering of double JPEG compression in the presence of image resizing between the two compressions. Our approach is based on the fact that previously JPEG compressed images tend to have a near lattice distribution property (NLDP), and that this property is usually maintained after a simple image processing step and subsequent recompression. The proposed approach represents an improvement with respect to existing techniques analyzing double JPEG compression. Moreover, compared to forensic techniques aiming at the detection of resampling in JPEG images, the proposed approach moves a step further, since it also provides an estimation of both the resize factor and the quality factor of the previous JPEG compression. Such additional information can be used to reconstruct the history of an image and perform more detailed forensic analyses.

T.-T. Ng and S.-F. Chang (2004), [17] In this paper, the ease of creating image forgery using image-splicing techniques will soon make our naive trust on image authenticity a tiling of the past. In prior work, we observed the capability of the bicoherence magnitude and phase features for image splicing detection. To bridge the gap between empirical observations and theoretical justifications, in this paper, an image-splicing model based on the idea of bipolar signal perturbation is proposed and studied. A theoretical analysis of the model leads to propositions and predictions consistent with the empirical observations.

T. M. P. Rajkumar and Mrityunjaya V Latte (2011) [18] in the paper, "ROI Based Encoding of Medical Images: An Effective Scheme Using Lifting Wavelets and SPIHT for Telemedicine" proposed renowned wavelet based image encoding scheme SPIHT is used by the proposed encoding scheme. The ROI coding commences with the selection of ROI and its corresponding resolution by the user. The diverse ROIs are encoded with diverse resolution (bpp) by applying lifting wavelet transform and SPIHT. Their experimental results illustrate that using lifting wavelet transform and SPIHT, the proposed ROI encoding scheme provides high compression ratio and quality ROI.

W. Luo, Z. Qu, J. Huang, and G. Qiu (2007)[19] In this paper, one of the most common practices in image tampering involves cropping a patch from a source and pasting it onto a target. In this paper, we present a novel method for the detection of such tampering operations in JPEG images. The lossy JPEG compression introduces inherent blocking artifacts into the image and our method exploits such artifacts to serve as a 'watermark' for the detection of image tampering. We develop the blocking artifact characteristics matrix (BACM) and show that, for the original JPEG images, the BACM exhibits regular symmetrical shape; for images that are cropped from another JPEG image and re-saved as JPEG images, the regular symmetrical property of the BACM is destroyed. We fully exploit this property of the BACM and derive representation features from the BACM to train a support vector machine (SVM) classifier for recognizing whether an image is an original JPEG image or it has been cropped from another JPEG image and re-saved as a JPEG image. We present experiment results to show the efficacy of our method.

Y. Q. Shi, C. Chen, W. Chen, and M. P. Kaundiny,(2007), [20] In this paper, the implementation of a few JPEG steganographic schemes such as OutGuess and F5, an additional JPEG compression may take place before data embedding. The

effect of this recompression on the performances of steganalyzers is experimentally studied and reported in this paper. Through a group of carefully designed experimental works, we show that the training and testing procedures adopted in classification are of great importance. An improper training and testing procedure may lead to poor steganalysis performance even for a powerful steganalyzer or an accurate performance comparison. Some other informative observations are presented in the paper as well.

Z. Lin , J. He , X. Tang and C.-K. Tang (2009), [21] In this paper, the quick advance in image/video editing techniques has enabled people to synthesize realistic images/videos conveniently. Some legal issues may arise when a tampered image cannot be distinguished from a real one by visual examination. In this paper, we focus on JPEG images and propose detecting tampered images by examining the double quantization effect hidden among the discrete cosine transform (DCT) coefficients. To our knowledge, our approach is the only one to date that can automatically locate the tampered region, while it has several additional advantages: fine-grained detection at the scale of 8×8 DCT blocks, insensitivity to different kinds of forgery methods (such as alpha matting and inpainting, in addition to simple image cut/paste), the ability to work without fully decompressing the JPEG images, and the fast speed. Experimental results on JPEG images are promising.

Z. Qu, W. Luo, and J. Huang (2008), [22] In this paper, the artifacts by JPEG recompression have been demonstrated to be useful in passive image authentication. In this paper, we focus on the shifted double JPEG problem, aiming at identifying if a given JPEG image has ever been compressed twice with inconsistent block segmentation. We formulated the shifted double JPEG compression (SD-JPEG) as a noisy convolutive mixing model mostly studied in blind source separation (BSS). In noise free condition, the model can be solved by directly applying the independent component analysis (ICA) method with minor constraint to the contents of natural images. In order to achieve robust identification in noisy condition, the asymmetry of the independent value map (IVM) is exploited to obtain a normalized criteria of the independency. We generate a total of 13 features to fully represent the asymmetric characteristic of the independent value map and then feed to a support vector machine (SVM) classifier. Experiment results on a set of 1000 images, with various parameter settings, demonstrated the effectiveness of our method.

III. TECHNIQUES USED

1. Image scaling

In computer graphics, **image scaling** is the process of resizing a digital image. Scaling is a non-trivial process that involves a trade-off between efficiency, smoothness and sharpness. With bitmap graphics, as the size of an image is reduced or enlarged, the pixels that form the image become increasingly visible, making the image appear "soft" if pixels are averaged, or jagged if not. With vector graphics the trade-off may be in processing power for re-rendering the image, which may be noticeable as slow re-rendering with still graphics, or slower frame rate and frame skipping in computer animation.

Apart from fitting a smaller display area, image size is most commonly decreased (or sub-sampled or down sampled) in order to produce thumbnails. Enlarging an image (up sampling or interpolating) is generally common for making smaller imagery fit a bigger screen in full screen mode, for example. In "zooming" a bitmap image, it is not possible to discover any more there are several methods of increasing the number of pixels that an image contains, which evens out the appearance of the original pixels.

2. Scaling methods

An image size can be changed in several ways. Consider doubling the size of the following image:



3.2.1 Nearest-neighbor interpolation

One of the simpler ways of doubling its size is nearest-neighbor interpolation, replacing every pixel with four pixels of the same color:



The resulting image is larger than the original, and preserves all the original detail, but has undesirable jaggedness. The diagonal lines of the W, for example, now show the characteristic "stairway" shape. Other scaling methods below are better at preserving smooth contours in the image.

3.2.2 Bilinear interpolation

Bilinear interpolation produces the following result:



Linear (or bilinear, in two dimensions) interpolation is typically good for changing the size of an image, but causes some undesirable softening of details and can still be somewhat jagged. Better scaling methods include bicubic interpolation and Lanczos re-sampling.

In mathematics, **bilinear interpolation** is an extension of linear interpolation for interpolating functions of two variables (e.g., x and y) on a regular 2D grid.

The key idea is to perform linear interpolation first in one direction, and then again in the other direction. Although each step is linear in the sampled values and in the position, the interpolation as a whole is not linear but rather quadratic in the sample location (details below).

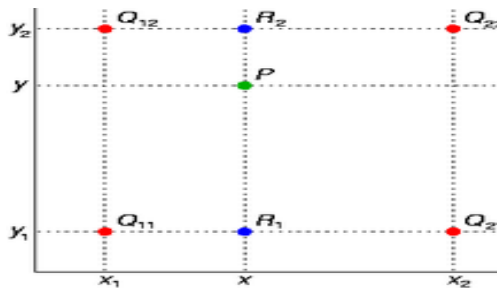


Figure 1.5 Interpolate points in bilinear

The four red dots show the data points and the green dot is the point at which we want to interpolate.

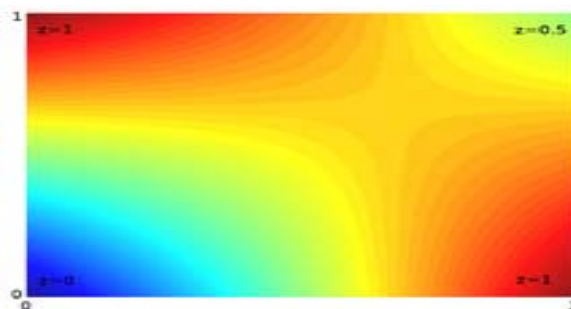


Figure 1.6: Bilinear interpolation on the unit square with the z-values 0, 1, 1 and 0.5

Example of bilinear interpolation on the unit square with the z-values 0, 1, 1 and 0.5 as indicated. Interpolated values in between represented by color.

3.2.3 Bicubic Interpolation For Image Scaling

There are a number of techniques one might use to enlarge or reduce an image. These generally have a tradeoff between speed and the degree to which they reduce visual artifacts. The simplest method to enlarge an image by a factor 2 say, is to replicate each pixel 4 times. Of course this will lead to more pronounced jagged edges than existed in the original image. The same applies to reducing an image by an integer divisor of the width by simply keeping every nth pixel. Aliasing of high frequency components in the original will occur. The more general case of changing the size of an image by an arbitrary amount requires interpolation of the colours between pixels.

The simplest method of resizing an image is called "nearest neighbour". Using this method one finds the closest corresponding pixel in the source (original) image (i,j) for each pixel in the destination image (i',j') . If the source image has dimensions w and h (width and height) and the destination image w' and h' , then a point in the destination image is given by

$$i' = i w' / w$$

$$j' = j h' / h$$

Where the division above is integer (the remainder is ignored). This form of interpolation suffers from normally unacceptable aliasing effects for both enlarging and reduction of images.

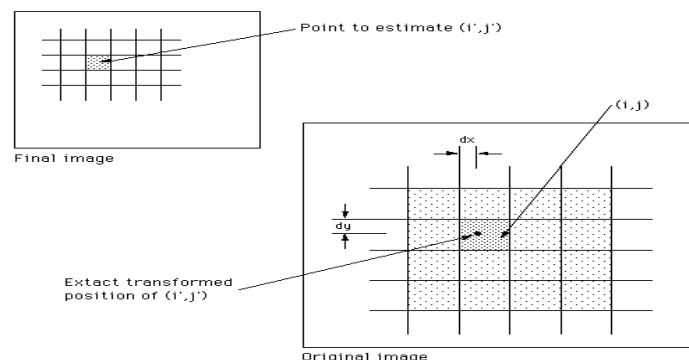
The standard approach is called bicubic interpolation, it estimates the colour at a pixel in the destination image by an average of 16 pixels surrounding the closest corresponding pixel in the source image. Another interpolation technique called bilinear interpolation will not be discussed here, it uses the value of 4 pixels in the source image. There are two methods in common usage for interpolating the 4x4 pixel, cubic B-Spline and a cubic interpolation function, the B-spline approach will be discussed here.

The diagram below introduces the conventions and nomenclature used in the equations. We wish to determine the colour of every point (i',j') in the final (destination) image. There is a linear scaling relationship between the two images, in general a point (i',j') corresponds to a non integer position in the original (source) image. This position is given by

$$x = i w' / w$$

$$y = j h' / h$$

The nearest pixel coordinate (i,j) is the integer part of x and y , dx and dy in the diagram is the difference between these, $dx = x - i$, $dy = y - j$.



The formulae below give the interpolated value, it is applied to each of the red, green, and blue components. The m and n summation span a 4x4 grid around the pixel (i,j) .

$$F(i',j') = \sum_{m=-1}^2 \sum_{n=-1}^2 F(i+m, j+n) R(m-dx) R(dy-n)$$

The cubic weighting function R(x) is given below.

$$R(x) = \frac{1}{6} [P(x+2)^3 - 4 P(x+1)^3 + 6 P(x)^3 - 4 P(x-1)^3]$$

$$P(x) = \begin{cases} x & x > 0 \\ 0 & x \leq 0 \end{cases}$$

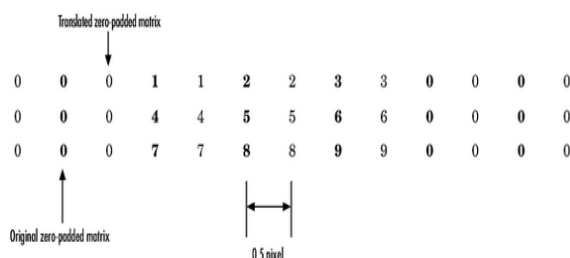
For bicubic interpolation, the block uses the weighted average of four translated pixel values for each output pixel value.

For example, suppose this matrix,

1	2	3
4	5	6
7	8	9

Represents your input image. You want to translate this image 0.5 pixel in the positive horizontal direction using bicubic interpolation. The Translate block's bicubic interpolation algorithm is illustrated by the following steps:

1. Zero pad the input matrix and translate it by 0.5 pixel to the right.



2. Create the output matrix by replacing each input pixel value with the weighted average of the two translated values on either side. The result is the following matrix where the output matrix has one more column than the input matrix:

0.375	1.5	3	1.625
1.875	4.875	6.375	3.125
3.375	8.25	9.75	4.625

3.3 Quantization

After the DWT, all the sub-bands are quantized in lossy compression mode in order to reduce the precision of the sub-bands to aid in achieving compression. Quantization of DWT sub bands is one of the main sources of information loss in the encoder. Coarser quantization results in more compression and hence in reducing the reconstruction fidelity of the image because of greater loss of information. Quantization is not performed in case of lossless encoding. In Part 1 of the standard, the quantization is performed by uniform scalar quantization with dead-zone about the origin. In dead-zone scalar quantizer with step-size Δb, the width of the dead-zone (i.e., the central quantization bin around the origin) is 2Δb as shown in Figure 1.7. The

standard supports separate quantization step sizes for each sub-band. The quantization step size (Δ_b) for a sub-band (b) is calculated based on the dynamic range of the sub-band values. The formula of uniform scalar quantization with a dead-zone is

$$q_b(i, j) = \text{sign}(y_b(i, j)) \left\lfloor \frac{|y_b(i, j)|}{\Delta_b} \right\rfloor$$

Where $y_b(i, j)$ is a DWT coefficient in sub-band band Δ_b is the quantization step size for the sub-band b. All the resulting quantized DWT coefficients $q_b(i, j)$ are signed integers.

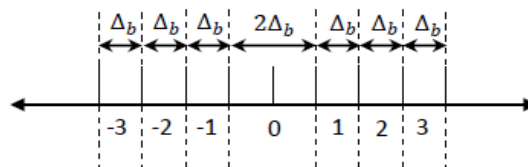


Figure 1.7: Dead-zone scalar quantizer

All the computations up to the quantization step are carried out in two's complement form. After the quantization, the quantized DWT coefficients are converted into sign-magnitude represented prior to entropy coding because of the inherent characteristics of the entropy encoding process.

3.4 Entropy Encoding

Physically the data are compressed by the entropy encoding of the quantized wavelet coefficients in each code-block in each sub-band. The entropy coding and generation of compressed bit stream in JPEG2000 is divided into two coding steps: Tier-1 and Tier-2 coding.

Tier-1 Coding: In Tier-1 coding, the code-blocks are encoded independently. If the precision of the elements in the code-block is p , then the code-block is decomposed into p bit-planes and they are encoded from the most significant bit-plane to the least significant bit-plane sequentially. Each bit-plane is first encoded by a fractional bit-plane coding (BPC) mechanism to generate intermediate data in the form of a context and a binary decision value for each bit position. In JPEG2000 the embedded block coding with optimized truncation (EBCOT) algorithm [2] has been adopted for the BPC. EBCOT encodes each bit-plane in three coding passes, with a part of a bit-plane being coded in each coding pass without any overlapping with the other two coding passes. That is the reason why the BPC is also called fractional bit-plane coding. The three coding passes in the order in which they are performed on each bit-plane are significant propagation pass, magnitude refinement pass, and cleanup pass. The binary decision values generated by the EBCOT are encoded using a variation of binary arithmetic coding (BAC) to generate compressed codes for each code-block. The variation of the binary arithmetic coder is a context adaptive BAC called the MQ-coder, which is the same coder used in the JBIG2 standard to compress bi-level images. The context information generated by EBCOT is used to select the estimated probability value from a lookup table and this probability value is used by the MQ-coder to adjust the intervals and generate the compressed codes. JPEG2000 standard uses a predefined lookup table with 47 entries for only 19 possible different contexts for each bit type depending on the coding passes. This facilitates rapid probability adaptation in the MQ-coder and produces compact bit streams.

TIER-2 Coding and Bit stream Formation: After the compressed bits for each code-block are generated by Tier-1 coding, the Tier-2 coding engine efficiently represents the layer and block summary information for each code-block. A layer consists of consecutive bit-plane coding passes from each code-block in a tile, including all the sub-bands of all the components in the tile. The block summary information consists of length of compressed code words of the code block, the most significant

magnitude bit-plane at which any sample in the code-block is nonzero, as well as the truncation point between the bit stream layers, among others. The decoder receives this information in an encoded manner in the form of two tag trees. This encoding helps to represent this information in a very compact form without incurring too much overhead in the final compressed file. The encoding process is popularly known as Tag Tree coding.

IV. CONCLUSION AND RESULTS

As the thesis, presents a practical algorithm for the reverse engineering of a doubly compressed JPEG image when a resizing step has been applied between the two compressions. The method aims at exploiting the fact that previously JPEG compressed images tend to have a near lattice distribution property (NLDP), and that this property is usually maintained after a simple image processing step and subsequent recompression. The results demonstrate that in the presence of prior knowledge regarding the possible resizing factors, the proposed algorithm is usually able to detect a resized and recompressed image, provided that the quality of the second compression is not much lower than the quality of the first compression. When the resizing factor has to be estimated, the detection performance is usually lower, however it remains comparable to or better than that of previous approaches. Differently from existing techniques, the proposed approach is also able to estimate with a reasonably good performance some parameters of the processing chain, namely the resizing factor and the quality factor of the previous JPEG compression. This represents an important novelty with respect to the state of the art, since it may open the way to more detailed forensic analyses.

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