International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 18, Issue 01) and (Publishing Month: December 2014)
(An Indexed, Referred and Impact Factor Journal)
ISSN (Online): 2319-6564
www.ijesonline.com

Anti Compression Forensics for Medical and Satellite Images

Arkendu Bhowmik[1] and Deepti Jaglan[2]

[1]**M.Tech Scholar, N. C. College of Engineering, Israna, Panipat, Haryana (India)**
arkendub@gmail.com

[2]**Assistant Professor, N. C. College of Engineering, Israna, Panipat, Haryana (India)**

Abstract

Compression is a process by which the description of computerized information is modified so that the capacity required to store or the bit-rate required to transmit it is reduced. This paper describes a technique based on total variation to detect the manipulation in the image. The technique checks whether the given image is original or the dithered noise is added to the compressed image to show it as original. The technique is used to analyze the DICOM and the TIFF images. The dithered noise detection phenomena use the symmetric property of the medical images and the reference image property of the satellite images. The simulation of the technique shows the effectiveness of the technique.

***Keywords**: Anti-forensics, TV, Q, DICOM, TIFF.*

1. Introduction

Images are very important documents nowadays [1], to work with them in some applications they need to be compressed, more or less depending on the purpose of the application. Image compression is an application of data compression that encodes the original image with few bits. The objective of image compression is to reduce the redundancy of the image and to store or transmit data in an efficient form [2]. There are some algorithms that perform this compression in different ways; some are lossless [1] and keep the same information as the original image, some others loss information when compressing the image. Some of these compression methods are designed for specific kinds of images, so they will not be so good for other kinds of images. Anti-forensics is compressive for assessing the forensics methods and is helpful for improving their reliability. The study of anti-forensic operations may also lead to the development of techniques capable of detecting when an anti-forensic operation has been used [3]. Furthermore, anti-forensic operations may be used to provide intellectual property protection by preventing the reverse engineering of proprietary signal processing operations used by digital cameras through digital forensic means. To the best of our knowledge, there are only two existing anti-forensic techniques: a set of operations designed to render image rotation and resizing undetectable and an technique to synthesize colour filter array patterns [4][5]. In the JPEG compression standard, a greyscale image is first divided into B non-overlapping pixel blocks of size 8×8. Then, the DCT of each block is computed. Let $x_i^b, 1 \leq b \leq B, 1 \leq i \leq 64$ denote the i-th coefficient of the b-th block according to some scanning order (e.g. zig-zag).Let $X_i = [X_i^1, \ldots, X_i^b]^T$ denote the set of DCT coefficients of the i-th subband. Each DCT co-efficient $X_i^b, 1 \leq i \leq 64$, is quantized with a quantization step size q_i as given by the JPEG quantization table. Note that the JPEG quantization table is not specified by the standard. The quantization levels Y_i^b are obtained from the original coefficients X_i^b as $Y_i^b = \text{round}\left(\frac{X_i^b}{q_i}\right)$. The quantization levels are entropy coded and written in the JPEG bitstream [3]. When the bitstream is decoded, the DCT values are reconstructed from the quantization levels as $\widehat{X_i^b} = q_i Y_i^b$. Then, the inverse DCT is applied to each block, and the result is rounded and truncated in order to take integer values on [0; 255]. Since the quantized coefficients $\widehat{X_i^b}$ can only assume values that are integer multiples of the quantization step size qi , the histogram of quantized coefficients of the i-th DCT subband, i.e. $\widehat{X_i} = [\widehat{X_i^1, \ldots, X_i^B}]$,is composed of a train of spikes at integer multiples of q_i The process of rounding and truncating the decompressed pixel values perturbs the comb-like distribution of $\widehat{X_i}$, as it can be recovered at the decoder; however, the DCT coefficient values typically remain tightly clustered around integer multiples of qi , thus revealing that: a) a quantization process has occurred; and b) which was the original quantization step [6]. Our present work is based on anti-forensic analysis of medical and satellite images. Medical imaging is a regulation within the medical arena which makes use of technology to acquire images of inside the human body [7]. These images are utilized in analytics, as training tools, and in regular healthcare. This sometimes specified as diagnostic imaging, because it is often helps doctors to diagnose easily. One kind of medical images is DICOM. DICOM not only stores the image, but also some details such as patient name, patient-id and date scanned etc. DICOM varies from other data formats, as it contain groups of information together into a data set. A satellite image, for example, commonly has multiple bands representing different wavelengths from the ultraviolet through the visible and infrared portions of the electromagnetic spectrum. Landsat imagery, for example, is data collected from seven different bands of the electromagnetic spectrum [8]. Bands 1–7, including 6, represent data from the visible, near infrared, and mid-infrared regions. Band 6 collects data from the thermal infrared region. Another example of a multiband image is a true colour ortho-photo in which there are three bands, each representing either red, green or blue light. Multiband imagery is usually stored in three formats: the band sequential method (.bsq), the band interleaved by line method (.bil), and the band interleaved by pixel method (.bip). The band sequential method stores the values of an image band as one file. If an image has seven bands then the data set has seven consecutive files, one for each band. The band interleaved by line method stores the values of all the bands in one file, row by row. The band interleaved by pixel method stores the values of all the bands by pixel in one file.

2. Existing Work

Our method is somewhat inspired by the work of Farid [9]. There, doubly compressed portions of a picture are detected by re-compressing the analyzed image at different quality factors. Briefly, when the quality factor matches one of those used for a certain image region, the differences between the analyzed image and its re-compressed version tend to be locally small, thus indicating double compression. Similarly, we study the mean-square-error distortion between the recompressed version of the attacked image and the original compressed image. We show that the distortion is completely annihilated only if the image is re-compressed at the same quality factor. Conversely, when the quality factor used for re-compression is higher, the dithering signal contributes to a non-negligible distortion, which is clearly visible as noise [10]. Differently from [9], however, we do not have access to the original compressed image when computing the mean-square error distortion after re-compression. Nevertheless, we observe that the dithering signal introduces noise-like artifacts in the recompressed image, which are clearly visible when the quality factor is higher than the original. Therefore, we measure the noisiness of re-compressed images by means of the total variation (TV), i.e. the l1 norm of the spatial first-order derivatives. This metric has been widely used in the field of denoising to quantify the presence of noise in natural images [11]. According to the proposed method, the forensic analyst re-compresses the (possibly) attacked image at different quality factors, and analyzes the TV of the re-compressed images. This analysis enables to automatically detect whether the image has been attacked and, in that case, to estimate the quality factor of the original compressed picture. The analysis [12] suggests that it is possible to identify anti-forensically dithered images by checking whether the noise introduced is annihilated after requantization. Unfortunately, in practice we do not have access to the original JPEG-compressed image in order to compute the MSE distortion after requantization. Nevertheless, we observe that the presence of the dithering signal in the spatial domain can be detected using a blind noisiness metrics. To this end, any metrics that can robustly measure the amount of noise present in an image could be employed. In the following, we adopt the total variation (TV) metrics, which is defined as the norm of the spatial first-order derivatives of an image. The total variation is more sensitive to small and frequent variations of pixel values due to noise, than to abrupt changes corresponding to edges. Hence, it is widely adopted as part of the objective function of optimization algorithms used for image denoising. In signal processing Total Variation denoising also known as total variation regularization is a process, most often used in digital image processing, that has applications in noise removal. It is based on the principle in which signals has excessive and possibly spurious detail regarding high absolute gradient. The behaviour of total variation (TV) is general, and applies also to different kinds of visual content. Therefore, we propose to analyze the $TV(Q_A)$ curve in order to devise a detector that identifies when the traces of compression. Therefore in lieu to the study [12], performance and analysis to our previous work we derived from the examined images that:

a. The dithered image is distorted with respect to the JPEG-compressed image.

b. Characterize analytically the distortion in the DCT domain, showing that it is a function of both the distribution of the original transform coefficients and the quantization step size. In conclusion we get that the energy of anti-forensic dithering is concentrated in the middle DCT frequencies, thus resulting in a grainy noise in the spatial domain. The mean-square-error (MSE) distortion $\widehat{D}_i$ between the JPEG-compressed coefficients $\tilde{X}_i$ and the dithered coefficients Y_i in the i-th subband can be measured directly in the DCT domain, since the transform is orthonormal [12]. That is

$$\widehat{D}_i = \frac{1}{B}\sum_{b=1}^{B}(Y_i^b - \tilde{X}_i^b) = \frac{1}{B}\sum_{b=1}^{B}(N_i^b)^2 \quad (1)$$

Since the distribution of the dithering signal is known from

$$f_{N_i}(n|\tilde{X}_i = 0) = \begin{cases} \frac{1}{c_0} e^{-\hat{\lambda}_i|n|} & if -\frac{q_i}{2} \le n < \frac{q_i}{2} \\ 0 & otherwise, \end{cases} \quad (2)$$

Where $c_0 = (2/\hat{\lambda}_i)(1 - e^{-\hat{\lambda}_i q_i/2})$

Conversely, for the other coefficients

$$f_{N_i}(n|\tilde{X}_i = x) = \begin{cases} \frac{1}{c_1} e^{-sgn(x)\hat{\lambda}_i(n+q_i/2)} & if -\frac{q_i}{2} \le n < \frac{q_i}{2} \\ 0 & otherwise, \end{cases} \quad (3)$$

Where $c_1 = (1/\hat{\lambda}_i)(1 - e^{-\hat{\lambda}_i q_i})$

$$f_{N_1}(n) = \begin{cases} \frac{1}{q_i} & if -\frac{q_i}{2} \le n < \frac{q_i}{2} \\ 0 & otherwise, \end{cases} \quad (4)$$

It is possible to obtain an analytical expression of the expected value $D_i = E[\widehat{D}_i]$ where

$$D_i = \sum_{k=-\infty}^{+\infty} \Pr(\tilde{X}_i = kq_i) \int_{-q_i/2}^{+q_i/2} x^2 f_{N_i}(x|\tilde{X}_i = kq_i)dx \quad (5)$$

Where $\Pr(\tilde{X}_i = kq_i)$ represents the probability mass function of the quantized DCT coefficients. For AC coefficients, (8) can be rewritten according to the definitions given in (6), (7). That is

$$D_i = m_i^0 D_i^0 + (1 - m_i^0) D_i^1 \text{ for } 1 \le i \ge 64 \quad (6)$$

Where

$$D_i^0 = \int_{-q_i/2}^{+q_i/2} x^2 f_{N_i}(x|\tilde{X}_i = 0)dx \quad (7)$$

$$D_i^1 = \int_{-q_i/2}^{+q_i/2} x^2 f_{N_i}(x|\tilde{X}_i = kq_i)dx \quad (8)$$

and $m_i^0 = 1 - e^{-\lambda_i q_i/2}$ is the fraction of coefficients quantized to zero. For DC coefficients, the mean square error D_1 is equal to that of a uniform scalar quantizer, i.e. $D_1 = q_1^2/12$. Instead, for AC coefficients, an expression can be found in closed form by solving the integrals in (9) and (10), as a function of the quantization step size and the parameter of the Laplacian distribution [12].
That is:

$$D_i^0(q_i, \hat{\lambda}_i) = \frac{\hat{\lambda}_i^2 q_i^2 + 4\hat{\lambda}_i q_i + 8(1 - e^{\frac{\hat{\lambda}_i q_i}{2}})}{4\hat{\lambda}_i^2 (1 - e^{\frac{\hat{\lambda}_i q_i}{2}})} \quad (9)$$

$$D_i^1(q_i, \hat{\lambda}_i) = \frac{1}{4} q_i^2 + 2\frac{q_i}{\hat{\lambda}_i}\left(\frac{1}{1 - e^{\hat{\lambda}_i q_i}} - \frac{1}{2}\right) + \frac{2}{\hat{\lambda}_i^2} \quad (10)$$

3. Proposed Technique

The proposed technique detects that there is any compression done in the medical i.e. DICOM image. The technique is based on the fact the mostly medical images are symmetrical to its half. It means if we divide the image from its half then it gives two symmetrical portions example the lungs image etc. But it is not necessary but the image is symmetrical then the quality factor of the two points must be same. Never the less the centre is considered as the origin and left part as negative portion and right part as the positive portion. One more concept is taken the quality of images enhances toward the centre as compared to edges. This process also goes symmetrical from top and bottom. These two concepts lead to the creation of following algorithm to detect whether any dithered noise is added to the image or not. As if any dithered noise is added to compressed image then two symmetrical points will have the same Qa. But the total variation i.e. TV doesn't remains the same. The difference between the TV of two points will be greater than the average difference.

Proposed Algorithm
Medical image anti forensics (m, n, Q_a[][], TV[][])

The image is of order mXn and the Q_a is an array containing the quality factor of each point. The TV is also an array that contains the total variation of each point. The algorithm can be explained by flowchart.

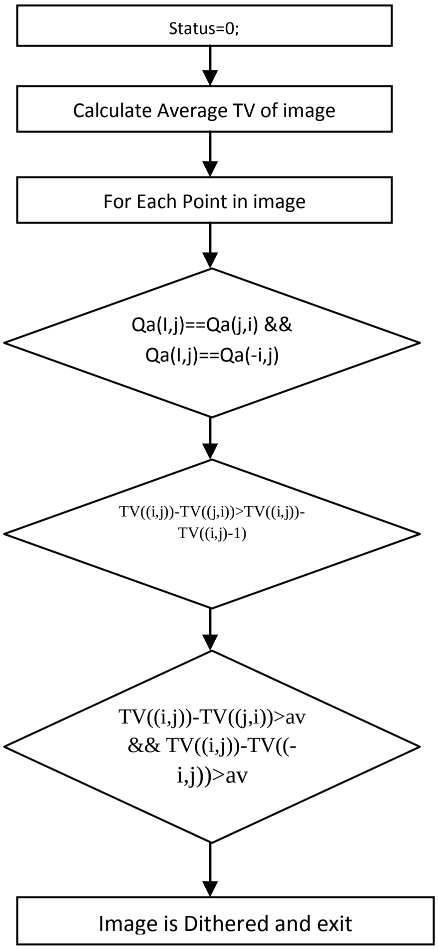

Figure 1: Proposed Work

The proposed algorithm can be applied to the tiff i.e. satellite images. But in the satellite images we have two images that are almost same. The procedure is applied to the two different images instead of one image i.e. no need to half the image. So the algorithm would be:

Satellite image anti forensics (m, n, Qa[][], TV[][], Qa1[][], TV1[][])

The image is of order m X n and the Qa is an array containing the quality factor of each point. The TV is also an array that contains the total variation of each point. Similarly QA1, TV1 are quality and total variation for reference image.

1. Status=0;
2. av=0;
3. For i=1:m
4. For j=1:n
5. av=av+ TV(I,j);
6. End
7. End
8. av=av/m*n
9. For i=1:m
10. For j=1:n
11. If Qa(i,j)==Qa(j,i) && Qa(i,j)==Qa1(i,j)
12. if(TV((i,j))-TV((J,i))>TV((i,j))-TV((i,j)-1))
13. if(TV((i,j))-TV((j,i))>av && TV((i,j))-TV1((i,j))>av)
14. status=1;
15. exit
16. End if
17. End if
18. End if
19. End
20. End
21. If status==1
22. Image is dithered
23. Else
24. Image is not dithered.
25. End if

4. Result and Discussion

The implementation of the proposed work is carried out on several images downloaded from the internet. All the pictures have a resolution of 512 X 384. In order to provide a fair comparison, we resample the images at the same resolution for testing. We split the total images in two sets of equal size. The first halves contain images that were compressed at a random quality factor. In order to restore the original statistics of the DCT coefficients, we added an anti-forensic dithering signal. The remaining half contained uncompressed original images. The implementation includes the comparison of the total variation of the various images. The histogram and the original signal comparison of the total variation of the original and the dithered image is shown in the Figure 2. This figure confirms that total variation is differing for the dithered image and the original image. The total variation of the dithered image is centred towards the 0. The histogram of the dithered image has higher frequencies as compared to the original image total variation. This total variation is used to get the dithered image from the set of original and dithered images as per the proposed technique explained in the previous section.

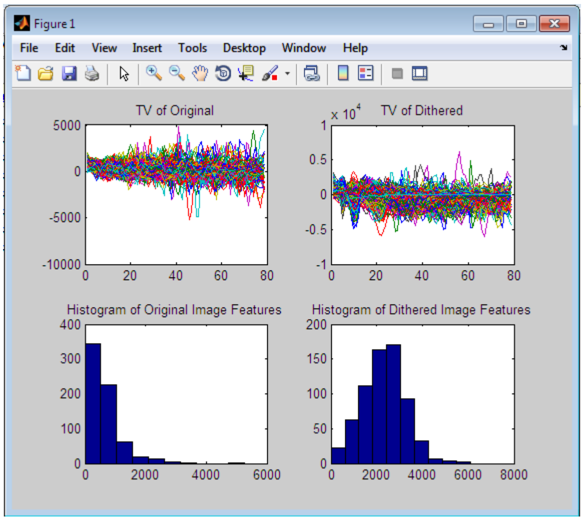

Figure 2: Comparison of TV of Original and Dithered Image

In Figure 3 the accuracy is plotted for the different values of the Q. The increase in the Q up to a threshold level increases the accuracy. The accuracy equal to 0.95 is achieved in the case of the unknown template which is higher than the existing values.

The Figure 4 shows the TP rate vs. FP rate graph. The true positive rate is the ratio of the total original dithered image found over the total images analyzed. While the false positive is the ratio of the total wrong dithered image analyzed over the total images analyzed. The increase in TP rate and the decrease in the FP rate are required.

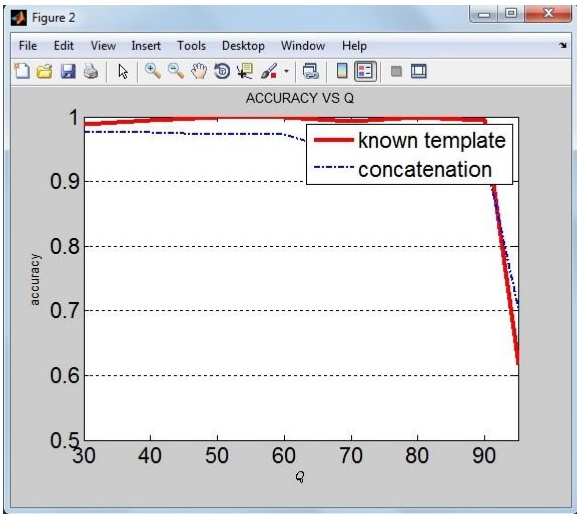

Figure 3: Accuracy vs. Q

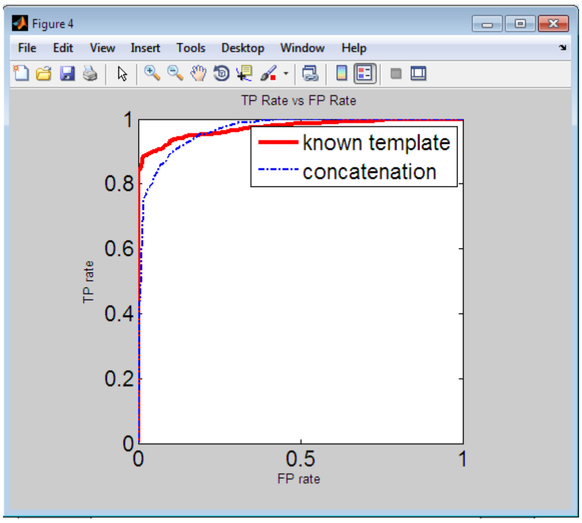

Figure 4: TP rate vs. FP rate

The above analysis shows that the accuracy is improved as compared to the known template results. The Increase in the TP rate and the decrease in the FP rate confirm the benefits of the proposed work.

5. Conclusion and Future Scope

This work technique detects that there is any compression done in the medical i.e. DICOM image or in the tiff images. The analysis done show that the accuracy is improved as compared to the known template result. The Increase in the TP rate and the decrease in the FP rate confirm the benefits of the proposed work. Future research will investigate the problem of compression anti-forensics in the field of video coding.

References

[1] Paula Aguilera, “Comparison of different image compression formats”, ECE 533 Project Report, Wisconsin College of Engineering, ECE, (2006).

[2] Wei-Yi Wei, “An Introduction to Image Compression”, Graduate Institute of Communication Engineering National Taiwan University, Taipei, Taiwan, ROC, (2008).

[3] Matthew C. Stamm, Steven K. Tjoa, W. Sabrina Lin, and K. J. Ray Liu, “Anti-Forensics Of Jpeg Compression”, Dept. of Electrical and Computer Engineering, University of Maryland, College Park, 978-1-4244-4296-6/10/ ICASSP 2010 IEEE.

[4] M. Kirchner and R. Bohme, “Hiding traces of resampling in digital images,” IEEE

Transactions on Information Forensics and Security, vol. 3, no. 4, pp. 582–592, Dec. 2008.

[5] M. Kirchner and R. B¨ohme, "Synthesis of color flter array pattern in digital images," in Proc. SPIE-IS&T Electronic Imaging: Media Forensics and Security, Feb. 2009, vol. 7254.

[6] Z. Fan and R. L. de Queiroz, "Identification of bitmap compression history: JPEG detection and quantizer estimation," IEEE Trans. Image Process., vol. 12, no. 2, pp. 230–235, Feb. 2003.

[7] Suresh Jaganathan and Geetha Manjusha M B, "dFuse: An Optimized Compression Algorithm for DICOM-format Image Archive", International Journal of Biometrics and Bioinformatics (IJBB), Vol. 5 Issue 2, (2011).

[8] K. Lohitha and Ch. Ramesh, "Satellite Image JPEG Compression", Indian Journal of Computer Science and Engineering (IJCSE), Vol. 3 No.4, pp.622-625, Aug-Sep (2012).

[9] H. Farid, "Exposing digital forgeries from JPEG ghosts," IEEE Trans. Inf. Forensics Security, vol. 4, no. 1, pp. 154 –160, March 2009.

[10] G. Valenzise, V. Nobile, M. Tagliasacchi, S. Tubaro, "Countering Jpeg Anti-Forensics", Dipartimento di Elettronica e Informazione Politecnico di Milano, Italy.

[11] L.I. Rudin, S. Osher, and E. Fatemi, "Nonlinear total variation based noise removal algorithms," Physica D: Nonlinear Phenomena, vol. 60, no. 1-4, pp. 259–268, 1992.

[12]]Giuseppe Valenzise, Member, IEEE, Marco Tagliasacchi, Member, IEEE, and Stefano Tubaro, Member, IEEE, "Revealing the Traces of JPEG Compression Anti-Forensics", IEEE Transactions On Information Forensics And Security, Vol. 8, No. 2, February 2013.