PHASE BASED DETECTION OF JPEG COUNTER FORENSICS

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ABSTRACT

Many recent techniques for forgery detection tried to counter noise dithering, which is considered to be the most successful technique for removing footprints of JPEG editing in countering forensics. In this paper we propose a novel idea of detecting any noise dithering that is typically adopted in removing footprints in counter anti forensics of images. This technique is based on detecting phase variations for DCT coefficients, for decoded JPEG images. We try to measure the level of coherence of phase values for coefficients and detect thresholded variations that would indicate some editing or tampering of images. The proposed technique is robust against noise dithering due to the fact that local homogeneous regions inherit distinctive phase values. These phase values are inconsistent with embedded or dithered noise signals that are considered to be out of phase and can be easily detected in noisy environments. Our proposed technique is compared with literature techniques for performance in noisy applications.

***Index Terms*—** image forensics, JPEG edits, anti forensic

1. INTRODUCTION

The recent availability of photo editing software with the wide-spread use of digital imagery in different applications has made it easier than ever to edit, manipulate and tamper the content of digital images. While manipulating different uncompressed image versions (i.e. bmp) can be easier to tamper or hack, compressed images with the widely used JPEG standard, are harder to edit and tamper undetectably, due to traces left by the JPEG compression. Several JPEG forensics and anti-forensics detection techniques have appeared in the last decade to detect either forgery of compressed images [1–3], or removals of hacking footprints in counter forensics [4, 5]. We note here that the noise dithering technique presented in [4, 5], has been considered in later literature, [6, 7], as a robust technique for countering forensics by introducing a dithering signal in the DCT domain that will match the distribution of tampered images to the original one and hide any possible hackings. This dithering signal has to be sufficient to fill in all gaps, but if it exceeded a certain limit it can also be detected. This detection can occur by recompressing the dithered image with different compression parameters such as the JPEG quantization matrix (QM) [8], or quantization step size [6], or the QM size [7]. In [9], another novel idea was introduced by recompressing decoded JPEG images until quantization noise saturates, and it has been reported to be the most robust technique in noisy environments as in [10, 11]. In [12], it has been agreed upon that the amount of noise significantly affects the performance of the detection of forgery, although it has also been highlighted that there are some sweet spots where the sensitivity of this detection does not get affected with bad image quality. In this paper we present a novel idea of exploiting spatial frequency phases (SFP) and spatial frequency magnitudes (SFM) to find distinctive local original image features to detect any forgeries. Spatial frequency phase and magnitudes have been long considered by human visual system and computer vision researchers [13, 14]. Marr in [15], designed several models to measure how humans perceive phase data and indicated that homogenous data samples tend to have close spatial frequency phase values, while noise samples and coefficients tend to be out of phase and can be easily detected from a phase prospective. As will be shown in the next sections, this technique of adopting phase data to detect forgery can locate possible noisy dithered regions of suspectable images with outstanding performance compared to current literature techniques. We also tested our technique with different noise levels to measure its robustness against noise. Section 2 gives an overview about our proposed phase based detection technique; section 3 shows how we employed this technique for countering forensics. Section 4 shows our comparison with literature techniques in [6] and [9], followed by conclusions in section 6.

2. PHASED BASED IMAGE ANALYSIS

Any spatial domain (pixel domain) consists of different sinusoidal frequencies in the transform domain, each of these frequencies is represented as a spatial frequency magnitude (SFM) and a spatial frequency phase (SFP), [15], as with

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any sinusoidal signal. If we take the Fourier transform of any $16x16$ image block, and note every Fourier coefficient in the i^{th} and j^{th} row and column as Z_{ij}, then a and b would correspond to the real and complex parts for that coefficient, $Z = a + ib$. R and θ would correspond the magnitude and phase of this complex coefficient as:

$$R = \sqrt{a^2 + b^2} \tag{1}$$

, while the phase component is calculated as:

$$\theta = \tan(\frac{a}{b}) \tag{2}$$

In the Human Visual System, the content of an image is analyzed through multiple independent spatial frequency channels [15]. Although these channels do not interact substantially with each other, there are some points in the image where the spatial frequency phase of all (or most) of the channels are coherent with each other, this is typical in homogenous image regions. These coherence points are perceived as visual features when the various spatial frequency components at these points, all have the same spatial frequency phase value, even if they do not enjoy similar spatial frequency magnitude values. When the phase of the various spatial frequency components in an image region are not coherent this would indicate presence of noise, as noise is typically out of phase and does not correlate well with different image contents. In noise dithering [4, 5], where added noise is supposed to fill in quantization gaps of decoded image coefficients, even though noise is supposed to have similar spatial frequency magnitudes in all image regions, for Fourier histogram coefficients (different frequencies), noise will not be phase coherent with the original image. Hence the degree of phase coherence in different image regions, can be used as an indication of the amount of added noise to this region of the image, which would correspond to whether it was edited or not. We note here that noise dithering would add noise coefficients that match the decoded image coefficients in magnitude, hence the Fourier coefficient histogram will not detect any magnitude discrepancies, but there is a large amount of phase inconsistencies, which is an indication of added dithered noise. In our proposed approach we measure the spatial frequency phase coherence across the suspectable image, especially for homogenous image regions where a high level of phase coherence is expected and try to detect any region of phase mismatch (incoherence) which would correspond to added noise.

3. DETECTION OF NOISE DITHERING

In detecting noise dithering for our suspectable JPEG compressed image, perform the following steps:

1. Measure the amount of phase coherence for every 16x16 Fourier block of decoded coefficients by measuring the histogram θ for all block Fourier coefficients.
2. Construct an SFP image that consist of phase values, it only consist of these 16x16 blocks
3. Measure the local variance for each 16x16 pixel values of the original image, that corresponds to a specific 16x16 phase value block.
4. If a 16x16 block has a large amount of edges (phase non smooth peaks) with a low variance value of its 8x8 pixel block, this would indicate that this block has been edited or hacked, phase values for this block would a lot of discrepancies and would have a high variance value.

We note here that the local variance measured in step 3, is just a suggested methodology to detect if this block of the image is likely to be edited or not. This is performed based on the hypothesis that a low variance region would correspond to a homogenous region and any phase incoherence in this region would indicate some editing, as in noise dithering we inject noise just to match the DCT coefficient distribution without considering any phase inconsistency. We also note that noise is typically out of phase and any dithered noise would have a phase component (SFP) that is random and would not match the original region phase data.

4. EXPERIMENTAL RESULTS

We adopted the successful technique of [4, 5] in injecting noise in different homogeneous, nonhomogeneous and edge image regions and tried to detect possible forgeries and hackings with our proposed technique. It was our own belief, that phase data can not be adjusted with any type of dithering while adjusting the edited image region.
We compared our detection performance with several recent literature techniques as in [9], [6]. In our tested data set of images we selected 280 images that are JPEG compressed with different quality factors ranging from 30 to 90, which indicates different noise levels. For each image we also made a dithered version, where a counter forensic dithered noise signal is added in different regions of the image. These different regions would be homogenous, nonhomogeneous or edge image regions. This would make our test samples 560 images (half original, and half forensically countered). One third of the dithered images were homogenous images, one third were nonhomogenous and one third were edge images. Fig.1 shows the detection performance of our phase coherence based anti-forensic technique for JPEG images compressed with different Quality factors (30 to 90), for homogenous regions. Performance of the most recent successful literature techniques is also illustrated in Fig.1 for homogenous regions. Fig.2 shows the same comparison of Fig.1 but for the 3 types textures.
Fig.3 shows an edited image with some dithering around the embedded object (door) in a homogenous region and the detected phase inconsistency in it. In our simulation results we

measured the level of phase coherence of all three types of images for both original and dithered versions. The resulting output was just a binary value of edited or not edited. While all original images were correctly classified as not edited images, different classifications were obtained for dithered images based upon region type and JPEG quality factor. In our experiments we selected an accuracy metric as our performance metric for forgery detection. This accuracy metric is defined as the number of correctly identified noise dithered images as edited or not edited, to the total number of test sample images. This choice of accuracy is justified by the balanced database that we had that consisted of equal number of original and attached (edited or dithered) images.

We note here that phase coherence inconsistency detection was high for dithered homogenous regions, due to the fact that homogeneous transform coefficients tends to have a uniform spatial frequency phase value, and any injected noise would be out of phase and would introduce an amount of phase inconsistency that can be easily detected.

We also note that this detection measure would drop in non-homogeneous regions, as the amount of phase coherence is minimal by definition [13]. In edge regions detection was at a middle level of the previous two regions due to the fact that edges would correspond to typical regions in the image to be attacked, while the amount of phase coherence is less as edges represent a mix between low and sharp transition frequency coefficient values. Table 1 shows detection values for the three techniques with different quality factor values.

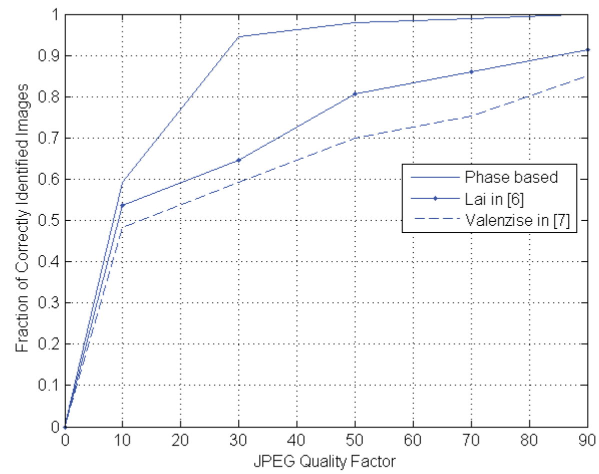

Fig. 1: Dithering detection performance against different quality factors for 3 recent literature methods

5. CONCLUSIONS

In this paper a novel technique was presented for the detection of forgery or tampering of JPEG images, the proposed approach relied on spatial frequency phase data that is embedded in spatial frequencies of the image and is primarily based on the assumption that noise is typically out of phase of its embedded region, hence any noise dithering can be detected especially in homogenous regions where any phase discrepancy is easily recognizable.

A promising future direction of research can be investigating the tradeoff between forgery detection sensitivity and human sensitivity for the image in noisy environments.

Table 1: Performance for nonhomogeneous/edge sample images

	Q=90	Q=70	Q=50	Q=30
Our Phase based	61/60	62/63	60/59	58/55
Lai in [9]	81/79	75/70	58/55	50/51
Valenzise in [6]	75/71	65/61	52/51	49/48

6. REFERENCES

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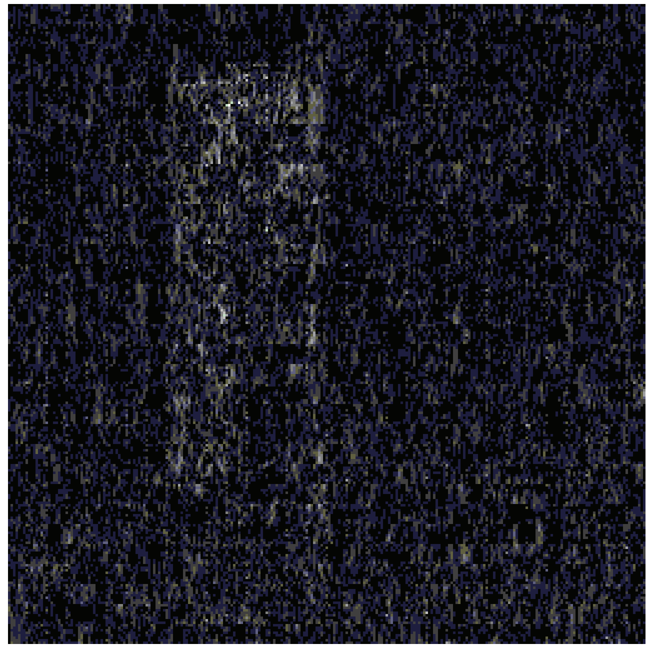
(a)



(b)

Fig. 3: A fake image with noise dithered around the embedded door with detected phase incoherence, white points indicate phase incoherence

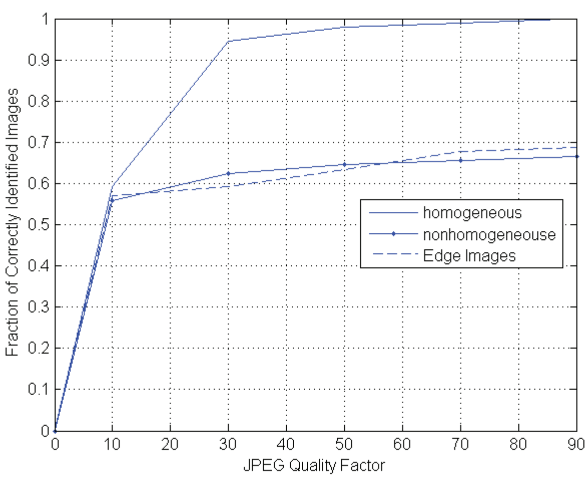


Fig. 2: Dithering detection performance against different quality factors for 3 types of sample images

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