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Contrast Enhancement Detection in Noisy Enhanced Images

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ABSTRACT: Digital images play important role in various applications across the internet. A lot of image editing software and tools are available today in order to correct the errors in images and provided you with high quality images. Even though it has benefits, this may be also helpful in making image forgery attacks. As a result the people may not be sure about the originality of an image. Contrast enhancement is a type of modification mainly used to adjust the brightness of an image globally. But users may also perform local contrast adjustments for creating forged images. It became problematic when such images used in security related applications. So techniques should be developed in order to ensure the integrity and authenticity of images. Contrast enhancement detection in noisy enhanced images reviews the forensic methods for detecting contrast enhancement in image by the histogram analysis of the corresponding images. Histogram peaks as well as the gaps as a result of contrast enhancement is taken as the main identifying feature. The system identifies specific contrast enhancement technique that is applied for an image. The proposed system is able to detect the enhancement even under the presence of noise in enhanced images.

KEYWORDS: Contrast enhancement; composite image; image forensics; image forgeries; neural network

I. INTRODUCTION

Today we are living in an internet world. In most of the security related applications in the internet people have to provide their images for verification purpose. Because of the wide spread availability of digital image editing software's and tools ,the scene information in an image is no longer believable to humans. Today digital image forgeries are common in internet. An image forger can easily create visually convincing photographs for making image forgeries. In image forgeries, attackers may usually use contrast enhancement as a final retouching operation in order to make their image more realistic. As a result there should emerge a need to verify the images originality to avoid such tampering.

There is a lot of works that deals with manipulation detection in digital images. Gamma correction is a commonly used operation for contrast enhancement. Gamma correction will be helpful for avoiding the detection of tampering in digital image [2], [7]. Contrast enhancement operation involves some pixel value mappings. This will be identifiable from the histogram of the enhanced image. So histogram analysis is mainly performed for manipulation detection. By detecting the contrast enhancement the main application is to identify the cut and paste type of image forgeries which is now common in internet [6]. In most of the works the drawback is that it fails to detect the enhancement in middle/low quality JPEG compressed images. The reason is that when a JPEG compressed image is contrast enhanced it also introduce some artifacts in the histogram. Our proposed method detect contrast enhancement in both uncompressed and JPEG compressed images. The histogram gaps as described in work [1] are considered as the main feature for detection.

The rest of the paper is organised as follows. Section II, reviews previous works on contrast enhancement forensics in digital images. In Section III the proposed method is described. Experimental result is presented in Section IV. The performance evaluation results are provided in section V conclusion is drawn in Section VI.

II. RELATED WORK

Most of the existing methods for contrast enhancement detection used the histogram analysis. It is clear from the histogram of an image about the changes left by contrast enhancement. The method proposed in [3], [4], [5] used the histogram analysis for detecting both locally and globally applied contrast enhancement. Then use this model to

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identify the changes in the histogram. The work [4] proposed algorithm to identify the arbitrary contrast enhancement applied to image to modify it and also to estimate the histogram of the unaltered version. The method proposed in [5] introduced two improved forensic methods of detecting contrast enhancement in digital images. The first method used a

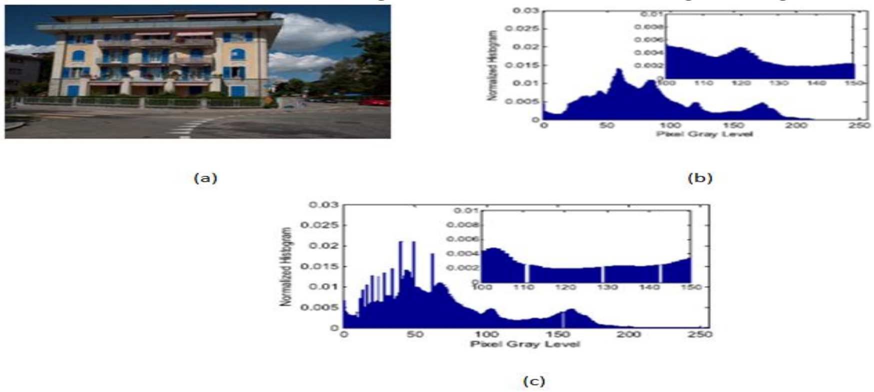

Fig.1. Histograms of raw image and contrast enhanced one.(a) raw image (b)histogram of raw image (c) enhanced with r=1.3

quadratic weighting function in order to measure the deviation in the histogram after enhancement from the original one. Second method measured the inter channel similarity and apply threshold to detect contrast.

With the rapid development of image forensic methods, anti- forensics field also emerged to fool the forensic methods. Anti-forensic methods focus on making a forged image or an altered image looks like a real image so that to avoid the forensic detection of image manipulation. The work [8] deals with forensic technique in order to cope with anti forensic attacks. The method relies on second order statistics derived from the co-occurrence matrix of the images.

The work [1] proposed algorithms for both globally and locally applied contrast enhancement detection. The histogram peaks/gaps as a result of contrast enhancement is considered as the main feature for detection. In [1] It is identified that histogram of an unaltered image having a smooth histogram as shown in Fig. 1(b). But when it is contrast enhanced the smoothness disappeared and introduced peaks as well as gaps which is shown in Fig. 1(c). So these peak/gap artifacts are considered as the main identifying feature for manipulation detection. But the method has a limitation. Contrast enhancement detection will be possible only if it is a last step of manipulation in digital image. That is any mild post processing activity done in enhanced image will fail the detection. As such the proposed methods are suitable to work in the scenario that contrast enhancement is the last step of manipulation applied to images.

Our proposed work is actually an extension of the work proposed in [1]. The proposed work deals with both globally and locally applied contrast enhancement detection. The histogram peaks/gap artifact analysis as in [1] is considered for detection. In addition to that a contrast enhancement type detection procedure is proposed. There are different types of contrast enhancement techniques used for improving the visual quality of images. In our method three types of contrast enhancements are mainly identified. The contrast enhancement techniques that we identified are gamma, linear and sigmoid contrast enhancements. That means for any contrast enhanced image, our proposed detection method will identify its type, if it belongs to any of the above mentioned categories. As an enhancement we tried to overcome the limitation of the existing method in work [1] against post processing activity. Global addition of noise to enhanced image is taken as the post processing activity. Our proposed method achieves high detection rate in the presence of noise in enhanced image as well as in contrast enhancement type detection.

III. PROPOSED METHOD

In section A algorithm for global contrast enhancement detection is performed. Section B describes local composite image detection. Section C deals with detection of post processing activity and in section D the detection of contrast enhancement type is described.

A. *Global Contrast Enhancement Detection*

The algorithm for global contrast enhancement detection is taken from the work proposed in [1]. Contrast Enhancement operation results in change of pixel intensity values. So the evidence of contrast adjustment can be get from the corresponding histogram. In this paper we check for the histogram peaks and gaps as a result of contrast enhancement which is used in latest technique [1].

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The contrast enhancement detection algorithm is as follows.

1. For an image, divide it in to non overlapping blocks.
2. Compute the gray level histogram of each block.
3. In order to detect a bin at the k^{th} Position as a gap, It should satisfy the following three conditions,
   3.1) the current bin should be null (h (k) =0).
   3.2) the average of neighboring bins h (k-1) and h (k+1) should be greater than a threshold τ
   3.3 Average of fixed number of bins should be greater than the threshold τ
4. Apply threshold to the number of gap bins to detect contrast enhancement.

Here the threshold τ is set as 0.001 as in [1]. The $2\omega_1 + 1$ bins are considered for averaging where $\omega = 3$ is the window size that we taken to avoid zero height gap bins which are incorrectly detected.

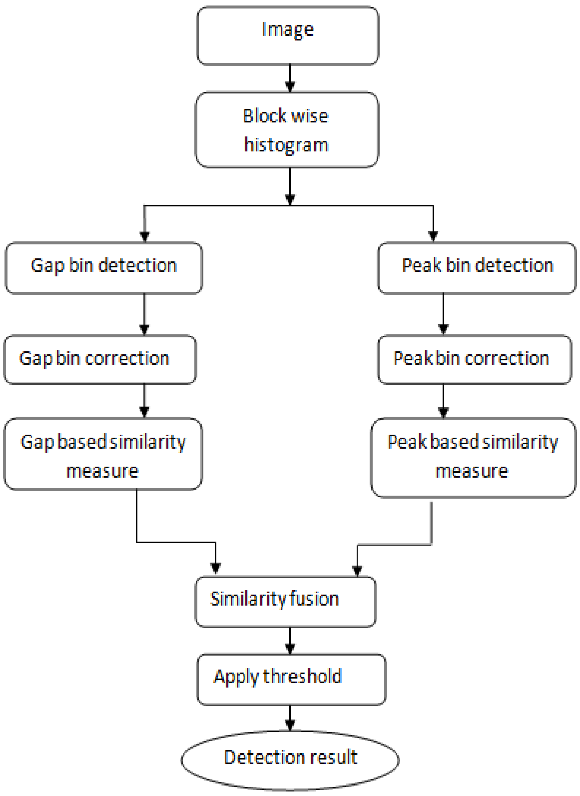

Fig.2. Flowchart of the composite image detection

B. *Composite image detection*

Today digital image forgeries are common in internet and other security related application. This actually decreases our trust in digital images. A composite image in other words a cut and paste type of image is usually created by attackers for making image forgeries. Usually different source images or their parts are combined in order to form a composite image. The significance of contrast enhancement in composite image is that different images have different colour temperature or contrast. So for making the composite image look like original, contrast adjustment is made to either one or both the source images. By detecting the inconsistencies in different parts of the image region as a result of this adjustment is considered as the feature for composite image detection. The flow chart of the composite image detection is given in fig. 2. The procedure for detection is described as follows.

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a) Peak/gap bin Detection

Gap bins are detected as described in section 3.1. Peak bins are considered as impulse noise. To detect peak bin first we have to clear gap bins from the histogram. The gap bins are filled with average of neighbouring bins. Then median filtering is applied to the gap filled histogram. To detect peak bin, thresholding the difference between the gaps filled histogram and the filtered version. Both the positions of gap bin and the peak bin are stored as a vector. If the k^{th} bin is a gap then the value of its position vector should be have a value 1, otherwise value will be zero.

b) Peak/gap based similarity measure

For finding inconsistency in image regions, first we have to select a reference position vector. Then for each image block finding the similarity between its position vector and this reference vector. If they are more similar which means that they coming from the same source region, otherwise they belongs to different source regions. Both peak based as well as gap based similarity measures are considered. Inconsistency between regional artifacts is considered for composition detection.

c) Similarity Fusion for Composition Detection

Both gap based as well as peak based similarity measures are find out and a fused similarity map is created. If this fused similarity value is greater than a threshold value *t*, then composition is detected. Here the threshold *t* is experimentally set as 0.002.

C. *Contrast Enhancement Detection in Noisy enhanced Images*

In [1] contrast enhancement detection will be possible only if it is a last step of manipulation in digital image. That is any mild post processing activity done in enhanced image will fail the detection.So the method proposed in [1] will work in situations where contrast adjustment is done as final step of modification. The proposed contrast enhancement detection improves the robustness against post processing activities. Proposed algorithm adds noise to enhanced images and detects the contrast in noisy enhanced image. Both random and salt and pepper noise are added to the enhanced image. The histogram peaks as result of contrast enhancement is considered for contrast enhancement detection. When a post processing activity is added to the enhanced image intensity value changed and introduced sudden peaks in the histogram. As a result the gaps will be disappeared from the histogram of the enhanced image. This is the reason why the prior contrast enhancement detection algorithms [1] fail in the presence of post processing. So in order to consider the bin at k^{th} position as a gap bin, we redefine the conditions in [1]. The conditions are given below.

1. The current bin should be less than half of the neighbouring bins.

$$h(k) < h(k-1/2) \ \ \& \ \ h(k) < h(k+1/2) \quad \textbf{(1)}$$

2. The average of neighbouring bins (2w1 + 1) bins should be larger than 3 times the threshold τ .

$$\frac{1}{2w_1+1}\sum_{x=k-w_1}^{k+w_1} h(x) > 3*\tau \qquad \textit{(2)}$$

Here the threshold τ is experimentally set as 0.001 and *w*=3.

D. *Contrast enhancement Type Detection*

Image enhancement plays important role in various fields. Contrast enhancement is one of the most important techniques for image enhancement. In this technique, contrast of an image is adjusted to improve the visual quality of an image. Contrast enhancement change the image pixel intensity value and the contrast of an image can be easily recognised from its histogram. There are various techniques that can be used for contrast enhancement process. In this section detection of specific contrast enhancement is performed. The detection of three types of contrast enhancement is mainly performed i.e. gamma, linear and sigmoid contrast enhanced images. A classifier based approach is used for detecting the contrast enhancement type detection. Artificial neural network is the classifier used for training. Because

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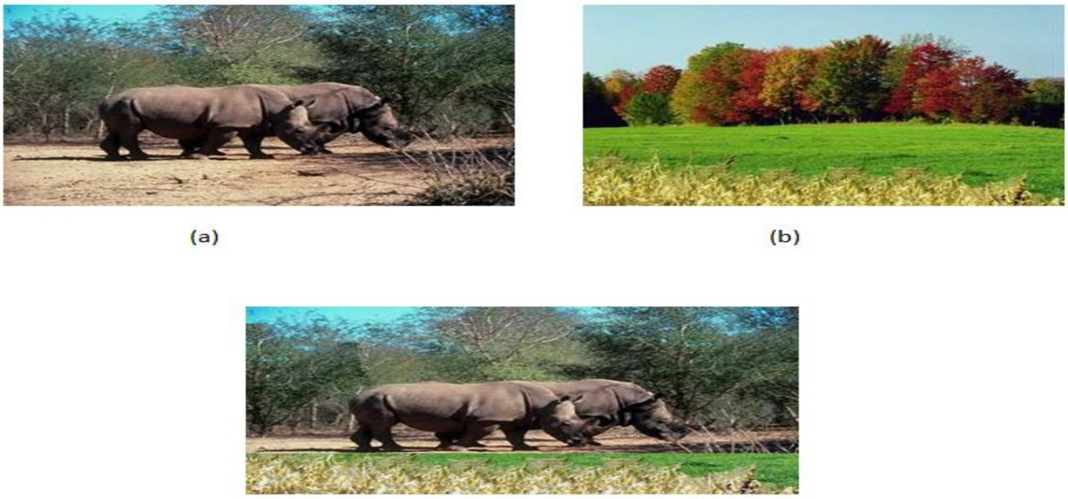
of the fact that, each type of contrast enhancement involves distinct pixel value mappings, this mapping will give the clues for detecting the type of contrast used. So the histogram cumulative sum is the feature extracted for training the network. For each test image it will be classified to any of the four categories i.e. whether it is gamma contrast enhanced or sigmoid contrast enhanced or linear contrast enhanced or it is an original image.



(c)

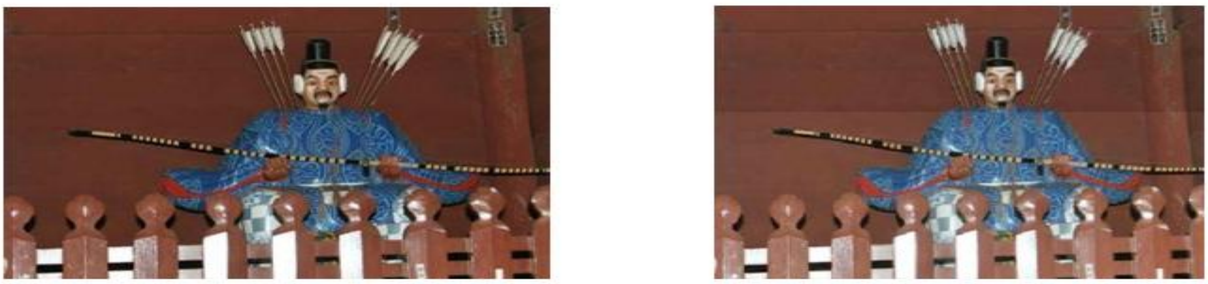
Fig.3. Composite image creation. (a) and (b) Two source images (c) Composite image created by combining the portions of the two source images with contrast adjustments.

IV. EXPERIMENTAL RESULTS

The entire system is implemented in mat lab and for checking the efficiency of our system experiments are conducted on different image datasets. Mainly two image datasets are used. One is UCID (Uncompressed Colour Image Database) dataset which consist of about 1024 uncompressed images on various topics such as natural scenes, man-made objects, indoors and outdoors and other is a collection of natural jpeg compressed images captured by different cameras.

A. *Global Contrast Enhancement Detection*

For checking the efficacy of global contrast enhancement detection algorithm, images are taken randomly from UCID image dataset and apply gamma correction with gamma values *r*=1.1, 1.3, 1.6. It is found that our proposed algorithm shows high detection rate with low pfa rate.



(a) (b)

Fig.4. Composition effect created on a single image. (a) Source image (b) Composite image created by applying two different gamma values r1=1.1and r2=1.3.

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B. *Composite Image Detection*

To evaluate the proposed composite image detection scheme, we manually create composite images. For creating a composite image first the image portions of two source images are combined. This two source images have different contrast or colour temperature. After combining these image portions, in order to provide a realistic look some contrast adjustments provided to portions of image. Thus we will get a composite image which look like original as shown in Fig.3(c) by combining Fig.3(a) and Fig.3(b) with some contrast adjustments. Then block wise similarity measurements are taken for the image regions. If the similarity value is 1 which means that image regions are more similar. If similarity value decreases, this means that a different mapping is found in image regions. In such a scenario the possibility for composition will be high. Also composite images are created in such a way that for a single image two different contrasts adjustments are done. For e.g. contrast enhancement $r1$=1.1 is applied in one portion of the image and $r2$=1.3 is applied in the remaining regions of the image in Fig. 4(a). The composite image thus created is shown in Fig.4 (b). We can also create composition effect like this. In both type of composite images our proposed composition algorithm shows high detection rate.

C. *Contrast enhancement Detection in the presence of Noise*

In [1] the enhancement detection will be possible only if it is a last step of manipulation in the digital image. The detection will be failed in the presence of any mild post processing activity. We investigated the reason behind this. Most of the contrast detection algorithms works based on the histogram analysis of the images. In [1] the zero height gaps in histograms are mainly considered as an evidence for contrast enhancement. When any other post processing activity is added (e.g. noise addition, scaling etc.) the gaps will be disappeared. This is the reason why the previous algorithm fails in the presence of post processing activity. In our method both random and salt and pepper noise are added to enhanced images as a post processing activity. As a result the gaps get disappeared, but introduced sudden peaks. The threshold value for contrast detection τ is increased. Our proposed method shows high detection rate in the presence of noise.

D. *Contrast Enhancement Type Detection*

Three types of contrast enhancement are performed for contrast type detection.

- Gamma correction
- Linear Contrast Enhancement
- Sigmoid contrast Enhancement

For creating gamma corrected images a gamma value of $r1$=1.1 is applied to images in the UCID dataset. For linear contrast enhanced image with alpha value l=0.25 is applied. Sigmoid contrast enhanced images are created by applying a cutoff value 0.3 and gain value 5. A classifier based approach is used for contrast type detection. Neural network is the classifier used for detection. The feature used for training the network is the histogram cumulative summation. For images in the UCID image dataset half size of the number of images are taken for training and remaining are considered as test images. For training we used scaled conjugate gradient back propagation (trainscg) as the training function. 'trainscg' is a network training function that updates weight and bias values according to the scaled conjugate gradient method. The search will be done along the gradient directions which gives faster convergence. In the testing stage, for each test image extracted the histogram sum and give it to the network for testing. The neural network tool box details will be available in [10].

V. PERFORMANCE EVALUATION

For evaluating the performance each test image will be classified whether it is correctly detected or incorrectly detected. As proposed in [9], by giving a classifier and its instance, there are four possible chances to occur. True positive case will occur when the instance is positive and also it is classified as positive. Suppose the instance is positive and classified as negative, it is counted as a false negative. Suppose the instance is negative and it is classified as negative, it is considered as a true negative. If the instance is negative and it is classified as positive, then it is false positive. The accuracy (AC) is the proportion of the total number of predictions that were correct. It is determined using the equation shown in (3) which is taken from [9]. The ROC (Receiver Operating Characteristics) curves are drawn based on the probabilities of true detection (Pda) and false alarms (Pfa) which is shown in Fig.5. In X axis false

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positive rate and in Y axis true positive rate is plotted. The ROC curve shows the accuracy of our proposed detection procedures.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (3)$$

Where TP = True Positives; TN = True Negatives; FP = False positives; FN =False Negatives.

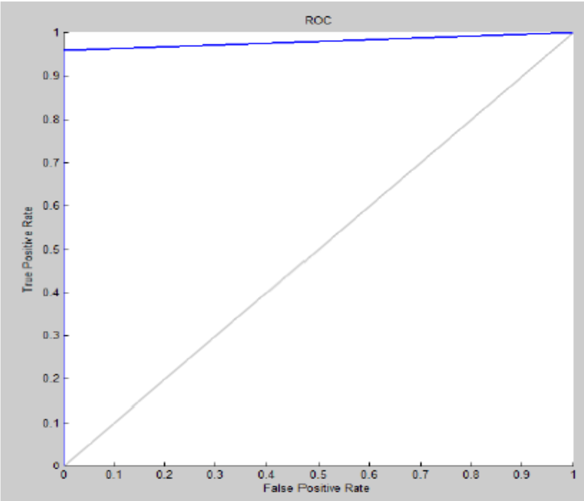

Fig.5. ROC curve for contrast enhancement detection

For testing the accuracy of our proposed contrast enhancement detection in the presence of noise, 200 images are tested and obtained p_d = 92% and p_{fa}=2% where p_d is the probability of true detection and p_{fa} is the probability of false alarms. In case of gamma contrast enhancement detection, 500 images are tested. The probability of detection p_d=89.6% and p_{fa}=9%.For sigmoid contrast detection obtained a p_d=92% and P_{fa}=8%. For linear contrast detection p_d=87% and p_{fa}=12%. The accuracy estimated for different detection algorithms are shown in table 1.

Table 1: Accuracy Estimated for Different Detection Techniques

Type of testing	**Total images tested**	**Accuracy (%)**
Contrast Detection in the presence of noise	200	95
Gamma contrast enhancement detection	500	90.4
Sigmoid contrast enhancement detection	500	93.7
Linear contrast enhancement detection	500	90
Composite image detection	500	95.7

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VI. CONCLUSION AND FUTURE WORK

As a retouching manipulation, contrast enhancement is typically used to adjust the global brightness and contrast of digital images. Malicious users Perform Contrast enhancement based manipulation for making image forgeries. The proposed method deals with detecting both globally and locally applied contrast enhancement. The zero height gap bins in gray level histograms were exploited as identifying features. Most of the Contrast enhancement detection techniques use histogram analysis for detection. But detection will be possible only if it is a last step of manipulation. So the proposed method deals with adding a post processing activity (noise addition) to the enhanced images and detecting contrast in the presence of post processing in enhanced image. Histogram peaks as a result of noise addition is mainly considered as the identifying feature for enhancement detection. Also introduce techniques for detecting the type of contrast applied for enhancing an image. A classifier based approach is used for this. Neural network is the classifier used for training. Histogram cumulative sum is the feature extracted for training. Proposed method improves the detection rate and also the robustness against post processing activity.

Since our method identifies the type of contrast applied for an image, in future it may possible to get back the original image from this enhanced image by investigating the pixel value mappings involved in enhancing the image.

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BIOGRAPHY

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