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Contrast Enhancement Based Forensic Detectability and Image Quality

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Abstract: **Contrast enhancement is usually used to adjust the global brightness and contrast of digital images. Malicious users may also locally perform contrast enhancement for creating a realistic composite image. As such it is necessary to detect contrast enhancement for verifying the authenticity and originality of the digital images. To detect the contrast enhancement involved manipulations in digital images here two novel algorithms are proposed. First one focus on the detection of global contrast enhancement, which is applied to the previously JPEG-compressed images. Second, is to identify the composite image created by making contrast adjustment on either one or both source images. Titanium-coated surfaces are prone to minute defects such as tiny cracks, which are not easily recognizable by the naked eye or optical microscopy. Two new thresholding methods, namely contrast-adjusted Otsu's method and contrast-adjusted median-based Otsu's method are proposed, for defect detection in the titanium-coated aluminium surfaces.**

Keywords: **Contrast Enhancement, Composite image, Edge Detection, Defect Detection.**

I. INTRODUCTION

The digital images are frequently stored in the JPEG format and are heavily compressed with a middle/low quality factor (Q) in real applications (Internet and mobile phones). The prior contrast enhancement forensic algorithms work under the hypothesis that the gray level histogram of an unaltered image exhibits a smooth curve. It is familiar that usually the low quality JPEG compression generates blocking artifacts, which cause unsmoothness and even locally dense peak bins in the gray level histogram. In such circumstances the existing approaches fail to detect contrast enhancement in the previously low quality JPEG-compressed images, because the smoothness of histogram becomes dissatisfied. To solve such a problem, i.e., to detect the global contrast enhancement not only in uncompressed or high quality JPEG-compressed images, but also in low quality ones is proposed. The main strategy relies on the blind identification of zero-height gap bins. In addition to global contrast enhancement, the detection of local contrast enhancement is also significant ie, to identify the cut-and-paste type of forgery, in which the contrast of one source region is enhanced to match the rest.

Although in the previous works composite image created by enhancing single source region could be identified, those enhanced in both-source regions may not. In this proposed system , a new method is introduced to identify single-source-enhanced and both-source-enhanced composite images. The Consistency between the peak/gap artifacts incured from different regions in the grey level histogram is checked for discovering the composite images.

Inspection and detection of defects on coated surfaces are crucial steps in the initial assessment of coating processes. Defects that are detected can then be modified to assure predetermined quality requirements. In case of severe defects, the coatings would be rejected. In addition, close observation of physical abnormalities in the coating would provide a possible mechanism of defects formation, and then can be implemented for the improvement of coating process. In this proposed system, a contrast-adjusted Otsu's method and contrast adjusted median-based Otsu's method were developed to make a distinction between coated and uncoated regions of titanium coated metal specimens, which is done by applying proper contrast adjustments and then using Otsu's method and median-based Otsu's method for the thresholding process. The thresholding process will classify each segments in the image into coated and uncoated regions.

II. BACKGROUND STUDY

A. M. Stamm and K. Liu - Blind forensics of contrast enhancement in digital images

A blind forensic algorithm is introduced in the proposed work for detecting the global contrast enhancement operations on digital images. The work is mainly based on the fact that, graylevel histogram of an unaltered images shows a smooth envelope whereas, contrast enhanced exhibits unsmoothness (peak/gap artifacts) in the gray level histogram. Here a novel algorithm is proposed to discover the use of histogram equalization. The methodology known as global contrast enhancement detection technique used here is as follows. This algorithm works by finding out the unique artifacts left by the histogram equalization. However, this paper only specifies about the detection of global contrast enhancement and not about the local enhancement in images.

B. M. C. Stamm and K. J. R. Liu - Forensic detection of image manipulation using statistical intrinsic fingerprints

Proposed work contains different methods for

1) Detecting globally applied contrast enhancement in image

Here Contrast enhancement operations are viewed as nonlinear pixel mapping which introduce artifacts into an image histogram. Nonlinear pixel mappings are separated into regions, where the mapping is locally contractive. The contract mapping maps multiple pixel values to the same output pixel value which cause sudden peak to an image histogram.

2) Detecting locally applied contrast enhancement in image

To mask the evidence of image tampering Contrast enhancement operation may be locally applied. Localized detection of these contrast enhancement operations can be used as evidence of cut-and-paste type forgery. The existing forensic technique is improved into a method to detect such type of cut-and- paste forgery.

3) Detecting Histogram equalization in image

Histogram equalization operation introduces sudden peaks and gaps into an image histogram, Just like any other contrast enhancement operations. The techniques are extended into method for detecting histogram equalization in image.

4) Detecting Noise in image

An Additive signal or noise can be globally applied to an image not only to cover visual evidence of image forgery, but also to fool the existing forensic detectors from forgery detection. Authenticity of image cannot be preserved Since forgery remains undetected. The technique used for nose detection is able to detect whether the image contains noise or not, such as speckle noise, Gaussian noise etc.

C. M. Stamm and K. Liu - Forensic estimation and reconstruction of a contrast enhancement mapping,

Once image alterations have been detected This work mainly focuses on extract the necessary information about the unmodified version of image and the operations used to modify it. An iterative method (based on probabilistic model) is proposed to estimate not only the contrast enhancement mapping used to alter the image but also the histogram of the unaltered version of the image. Also this model finds the histogram entries that occur mostly as a result contrast enhancement artifacts.

III. PROPOSED SYSTEM

An image can be manipulated by making any changes to them such as compression, embedding data on images etc. Image manipulations such as contrast enhancement can be performed by the attacker to avoid leaving visual clues after forging an image. Contrast enhancement is often referred to as one of the most important issues in image processing. Contrast enhancement is mainly used to adjust the brightness of the image. Attackers may perform contrast enhancement locally and globally for creating manipulated images. As a result, existing forensic techniques may contain unknown vulnerabilities that remains undetected. Inorder to improve existing forensic techniques here we are mainly focusing on detection of contrast enhancement forgeries in both

- JPEG images and
- Titanium-coated image (Microscopic images).

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IV. CONTRAST ENHANCEMENT DETECTION IN JPEG IMAGE

A. Global Contrast Enhancement Detection

The zero-height gap characteristic can be used to detect global contrast enhancement in digital images. The gap bins with zero height are always appearing in the histogram of contrast enhanced images. Detect the bin at k as a zero-height gap bin if it satisfies the following pseudocode:

$$\begin{cases} h(k) = 0 \\ min\{h(k-1), h(k+1)\} > \tau \\ \dfrac{1}{2w_1+1} \displaystyle\sum_{x=k-w_1}^{k+w_1} h(x) > \tau \end{cases}$$

If the number of zero-height gap bins is greater than the threshold value,contrast enhancement is detected, else remains undetected.

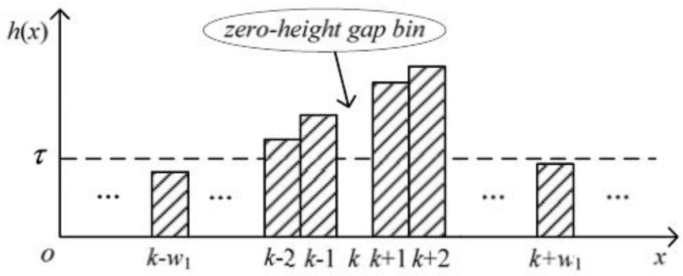

Fig. 1. Definition of a zero-height gap bin at *k*.

B. Source Enhanced Composite Image Identification

Identify the source-enhanced composite image created by making contrast adjustment on either single or both source images.

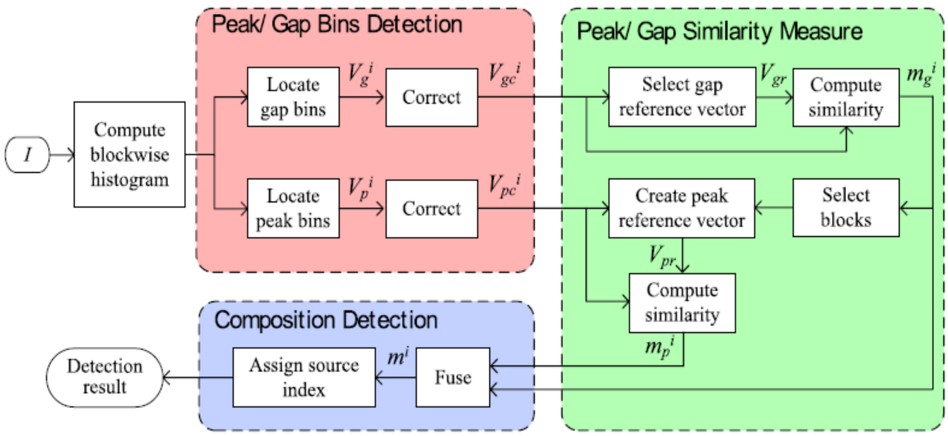

Fig.2. Flowchart of the composite image detection.

To find composition, the test image *I* is first divided into 8x8 Non overlapping blocks. Then locate gap bins and peak bins. The zero-height gap bins are detected as in global contrast enhancement. Inorder to make two source regions distinguishable, we should first set a reference position vector for either one source region i.e., either one image. Each block are then classified by the similarity between its position vector and the reference one. It is necessary to believe that the blocks with approximate similarity come from the same source image. The block containing largest number of zero-height gap bins is assumed to situate within one source region.The source index stores the orginal image value. Finally, output the result by Comparing the index values of the original and the blocks of images.

V. DEFECT DETECTION IN TITANIUM COATED IMAGE

Titanium coatings are used in the field of dies, coins, surgical instruments, etc. The reasons to coat cutting tools in a production is to increase tool life, to increase the production rate, and to improve the surface quality of the product. The advantages of Titanium coating include high hardness and adhesion, excellent ductility, good lubricity, tough resistance to wear and high chemical stability and corrosion. Also Ti coated surfaces are surfaces with uniform color. The physical abnormalities in the coating would provide an understanding of defects formation, and the knowledge gained can then be used for the improvement of coating process. In production environment, manufacturers usually adopt visual scrutiny techniques to detect product defects. In this proposed system, Two new thresholding methods are proposed, namely contrast-adjusted Otsu's method and contrast-adjusted median-based Otsu's method, for defect detection system for titanium-coated aluminium surfaces.

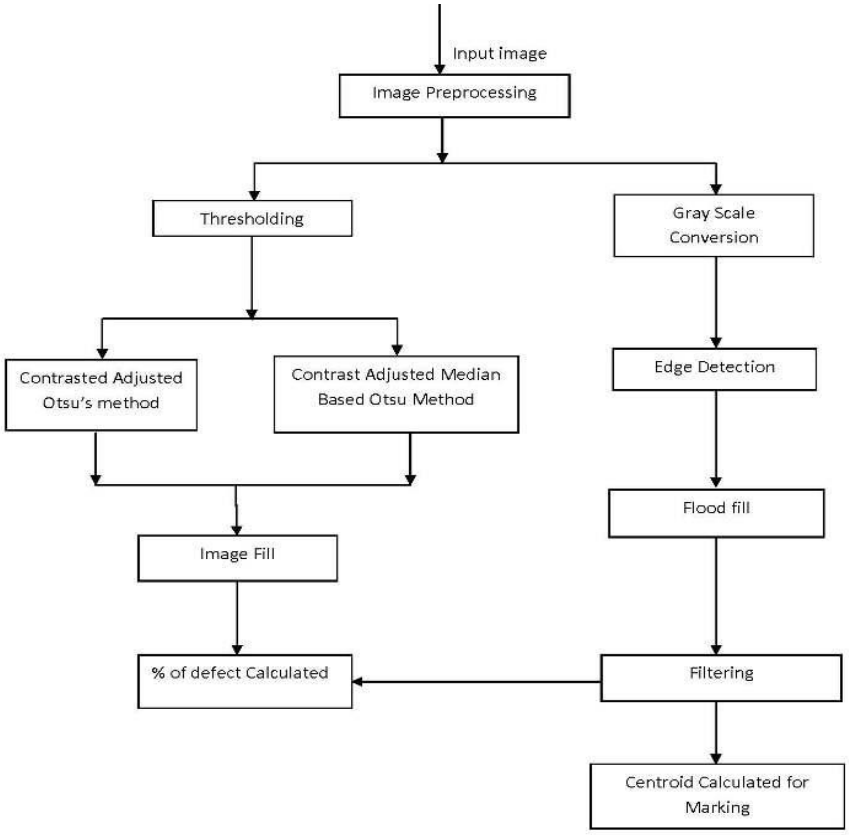

Fig .3. Block Diagram for Surface defect detection of Titanium Coated Surfaces

This system for defect detection on titanium coated surfaces with contrast adjustment consists of several modules:

1) Image of a titanium coated surface is acquired and cropped for selecting a portion of the image, and then enhances the image using suitable contrast adjustment technique.

2) Binarize the image using Otsu's thresholding method or median based Otsu's thresholding method. Binarization will represent the coated surface to 0 (black) using the image filling algorithm and the defect will be highlighted by representing it to 1 (white).

3) Make gray scale of the selected portion before edge detection. Uniform color is one of the properties of titanium coated surfaces. If any microscopic defect is present on the surface, it flood fills the complete image. Therefore canny edge detection algorithm is suitable for detecting edges and avoiding the unwanted noises. Select the primary color and detect the defect that occurs in the image.

4) In the defect detection stage, first calculate the centroid of the defects, which indicates the position of the defect. Next stage is, to calculate the surface area of defects with respect to the coated sample surface area. At last, the percentage of

the defect calculated to determine the extent of defects detectable using the proposed methods. Also, the proposed methods were able to correctly detect the highest number of predetermined defects in different sets of image resolution.

A. Image Acquisition & Contrast Adjustment

Image preprocessing is incorporated into the image acquisition state. Images are corrupted by different types of noises. It is very important to preserve quality of images (surface images for titanium coatings) for accurate observations for the given application.

Fig. 4 Image of Ti coated Surface

Ti coated surface has one of the feature such as uniform color on the entire region. ThereforeTi coatings are used in case of coins, dies, surgical instruments etc. They also provide long life by preventing the corrosion. Image with different resolution can be used for studying the features.

Contrast Adjustment

In the case of images of titanium coated surfaces, the rate of false detection increases due to the lightening and shadow effect. To reduce this rate of false detection, enhance the contrast of the image using the contrast extension method.

B. Thresholding and Image Filling

For defect Detection suitable thresholding technique is utilized to obtain the corresponding binary image.

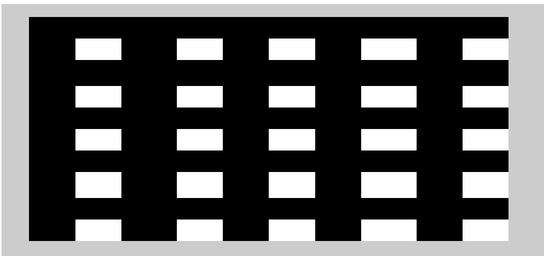

Fig. 5. Binary.

The defects are highlighted in a different color (white) as compared to the rest of the coating (black). The optimum threshold value t* can be calculated either by Otsu's method or by Median Based Otsu's method. The threshold t divides the image into two classes. 'C_0' is the foreground class and 'C_1' background class.

By Otsu's method

$$t^* = \underset{1\le t\le L}{argmin}\,\sigma_w^2 = \underset{1\le t\le L}{argmin}\{w_0(t)\sigma_0^2 + w_1(t)\sigma_1^2\}$$

By Median Based Otsu's method

$$t^* = \underset{1\le t\le L}{argmin}\{w_0 MAD_0(t) + w_1 MAD_1(t)\}$$

Where w_0 and w_1 are the occurrence of probabilities of the foreground and background class, MAD refers the mean absolute deviations. If the levels are >t*, then the pixels are converted to 1 and converted to zero if levels are <= t*. Binarization represents coated surface to black. Then fill the image using suitable algorithm.

Flood Fill Algorithm

The flood fill algorithm takes three parameters as input. A start node, a target color and a replacement color. The algorithm looks for all nodes in that are connected to the start node by a path of the target color and changes them to the replacement color.

Step 1: Find the location of the pixel and color.

Step 2: Replace color of the given pixel and all adjacent same colored pixel with the given color.

C. Edge Detection

Make gray scale of the selected portion before edge detection. The equation used for the conversion of gray scale image is as follows;

grayScale = (originalColor.R * .3) +(originalColor.G * .59) + (originalColor.B * .11)

Gray image is also well-known as an gray scale ,intensity or gray level image. The purpose of edge Detection is to considerably reduce the amount of data in an image,by preserving the structural properties that can be used for further image processing. Edge is a vital low level feature.it describe both shape and texture features. The most important properties of edge features are ability to describe shape of objects. Canny Edge Detection Algorithm is used for Edge Detection. In this module features based on an edge detector is extracted.

D. Defect Detection

First step is to filter the defect and analyze it. For that area of each defect is calculated. The area of each defect is expressed as 'A_k'(k = 1, 2…...N), and N is the number defects detected based on the number of connected components. The area is calculated based on the number of pixels m for the corresponding area of defects A_k, such that A_k = $a_1 + a_2 + a_3 + \ldots\ldots\ldots + a_m$.

The centroid value indicates the position of the defects. The centroid of the defect can be calculated using

$$C_{kx} = \frac{\sum c_{mx} a_m}{A_K} \quad , \quad C_{ky} = \frac{\sum c_{my} a_m}{A_K}$$ Where C_{kx} is the x-coordinate and C_{kx} is the y-coordinate.

In second step, The sample surface area is calculated to determine the area of defects with respect to the titanium coated sample surface area. The surface area of the coated samples was calculated based on the filled binary gradient mask.

In third step,The percentage of the sum of defected area as compared to the entire size of the coated-samples is calculated to find out the extent of defects that can be detectable using these proposed methods. The total defect surface area denoted as A_D , is obtained by the summation of surface areas of A_k for number of detected defects(N). i.e.,

$$\mathbf{A}_D = A1 + A2 + \ldots\ldots\ldots + AN = \sum_{k=1}^{n} Ak$$

Thus the percentage of defect Pd for each image can be calculated by

$$Pd = (\sum_{k=1}^{n} Ak \,/\, \mathbf{A}T) \times 100\%$$

VI. CONCLUSION

Contrast enhancement is normally used to alter the global brightness and contrast of digital images. Malicious users Perform Contrast enhancement based manipulation for making image forgeries. The proposed system detects both globally and locally applied contrast enhancement and distinguish between coated and uncoated regions of metal specimens.

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.

It was found that the two thresholding methods, contrast-adjusted Otsu's method and contrast-adjusted median-based Otsu's method in the proposed system were able to correctly detect the highest number of predetermined defects on high-resolution images of titanium-coated aluminum specimens.

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