DIGITAL RE-ESTABLISHMENT OF CRACK IN OLDER PAINTINGS BY FAST AND EFFICIENT CRACK DETECTION & RESTORATION ALGORITHM

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***Abstract*:** Several methods have been proposed for detection and removals of cracks in digitized paintings Cracks not only deteriorate the quality of painting but also question its authenticity. In this paper, cracks are identified by the M3 methods to identify cracks. After detecting cracks, the breaks which are wrongly identified as cracks are separated using region growing. Canny edge detection is used for identify the edges in images. Further, misidentifiedcracks are detected either by involving user intervention or by using a semi-automatic procedure based on region growing technique. Finally, crack interpolation also called crack filling is performed using order statistics filters so as to restore the cracked image. This methodology of detection and elimination of cracks in digitized paintings is shown to be very effective in preserving the edges also.
***IndexTerms*: Digital image processing, digitized paintings, crack detection, crack filling, top-hat transform methods, region growing algorithm, canny edge detection, bilateral filter.**

I. INTRODUCTION

Ancient paintings are cultural heritage for ones country which can be preserved by computer aided analysis and processing. These paintings get deteriorated mainly by an undesired pattern that causes breaks in the paint, or varnish. Such a pattern can be rectangular, circular, spider-web, unidirectional, tree branches and random and are usually called cracks. Cracks are caused mainly by aging, drying and mechanical factors like vibration, and human handling [1]. The paper aims is to classify cracks into paintings to aid in damage assessment. Keeping this things in mind we propose a new algorithm which uses feature extraction and segmentation in order to identify the defects in gray level digital images. In this work the minimum, maximum and median values are calculated for each row of the image to frame the feature vector. The high frequency components are eliminated using the median value of each row and at last the low frequency compo-nent image along with the median value of each row is used to detect the defected points with sudden intensity variation from the former picture element or sudden variation from the median value. The proposed work is divided in this paper as the second section consists of feature extraction and the next section contains elimination of high frequency components and the sub-sequent consist of identifying defects.

II LITERATURE REVIEW

2.1 Independent Component Analysis Methods:

Independent component analysis (ICA) is a computational method[9] for separating a multivariate signal into additive subcomponents supposing the mutual statistical independence of the non-Gaussian source signals. It is a special case of blind source separation.This Method was proposed by A. Serdaroglu In his research work revealed the use of Independent component analysis method along with wavelet transforms for identifying defects in textile fabric images. The idea behind this ICA method is to find the mean value and standard variance for the whole image. These two features are extracted to identify the defects. The original image pixel values are subtracted from the mean value and then will be divided by the standard variance. The intensities which are below certain value will be classified as a defected area. The following sections show the defected original image and the identified defected area.

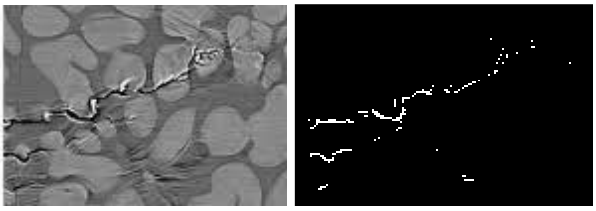

Figure 2.1(a) shows the original image and (b) shows defected region identified image

2.2 Optimal Gabor Filter Method:

In image processing, a Gabor filter, named after Dennis Gabor [4], is a linear filter used for edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. A set of Gabor filters with different frequencies and orientations may be helpful for extracting useful features from an image.The optimal Gabor filter method was proposed by Hamid Alimohamdi in his research work detecting skin defects in fruits. The 2D Gabor filter is applied on the image which has different scales and frequencies. The real and the imaginary parts are convoluted to form the filtered image. The Gabor wavelet function is given as,

$$\Psi(x,y)=\frac{1}{2\Pi\partial x\partial y}\exp\left[-\frac{1}{2}\left(\frac{x^2}{\partial_x^{\,2}}+\frac{y^2}{\partial_y^{\,2}}\right)\right]\exp(j2\Pi Wx) \quad (1)$$

The Gabor filter gives two types of output one the convoluted image and identified defected region image. The optimized filter is chosen by results based on convolution The Gabor filter gives two types of output one the convoluted image and identified defected region image. The optimized filter is chosen by results based on convolution.

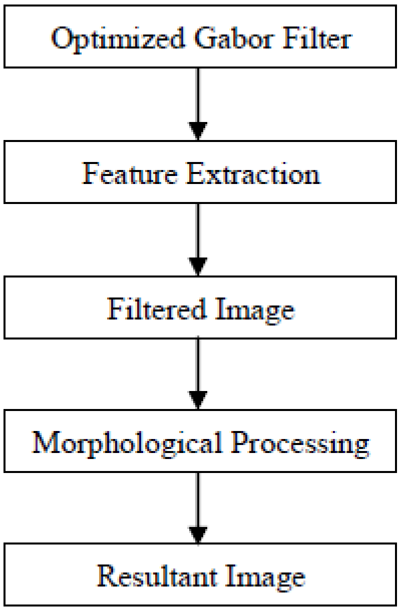

Figure 2.2. Flow Diagram of Gabor filter Method

The Optimized filter is chosen from varied scales and rotations. The Feature is extracted such as mean and standard variation. The optimum value is chosen by mean divided by square of standard deviation. The threshold value is chosen from the mean value with appropriate intensity variation to obtain the filtered image. The Filtered image is subjected to morphological operations such as dilation and erosion with the help of structural element to obtain the resultant image.

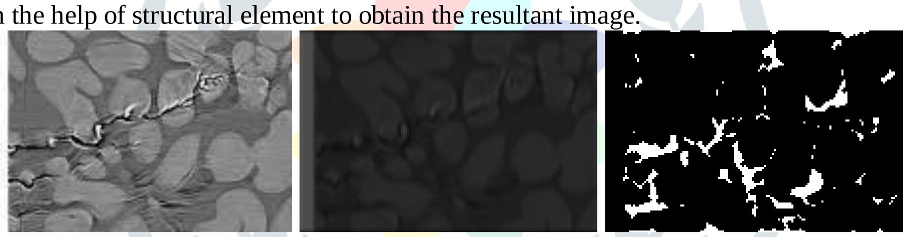

Figure 2.3. (a) Original image (b) Convoluted image (c) Segmented image

The above samples Fig 2.3 (a) is the original image, Fig 2.3 (b) is the convoluted image and Fig 2.3(c) is the identified defected region image. The third image results in false positives and

III PROPOSED WORK

3.1 **Feature Extraction**

After initial preprocessing the given image is subjected to feature extraction strategy. At first the given image is converted to a gray level image. Then the image is row wise bifurcated. The various parameters such as minimum, maximum and median value is calculated for each row of the image. The minimum is represented with the equation.

$$\text{Minimum} = \text{Min}(f(x,y)) \mid y = 1,2....N \quad \text{where } x = \text{integer constant} \quad (2)$$

where f(x, y) is the image and y varies from 1 to N and x re-mains stationary for a row. The same process is repeated for all rows. The collected minimum values are kept in a data structure which holds multiple values. The other step in feature extraction is to identify the maximum value of each row. The maximum value is identified by the following equation.

$$\text{Maximum} = \text{Max}(f(x,y)) \mid y = 1,2....N \quad \text{where } x = \text{integer constant} \quad (3)$$

In the above equation f(x, y) is the image where x is kept constant for a row and y varies within the stipulated range as mentioned in the equation. The third most feature is extraction of the median value for each row. The median value is represented using the following equation,

$$\text{Median} = x_m \mid (x_1, x_2, ...x_m, x_{m+1}, ...x_n) \quad \text{where n is odd} \quad (4)$$

The above equation states xm is the middle value of the particular row of the image when arranged in ascending order .The above case can be only be applied if the number of pixels in each row is odd. The median value is found for even number of pixels using the following equation,

$$\text{Median} = (x_m + x_{m+1})/2 \mid (x_1, x_2, \ldots x_m, x_{m+1}, \ldots x_n) \quad \text{where } n \text{ is even} \tag{5}$$

The above mentioned equation states in case the number of pixels in the row is even the middle value xm of the ascending order wise arranged row and the next value to middle value xm+1 is averaged to find the median value. The features Minimum, Maximum and Median are put together to frame the feature vector. The instead of collecting features for the whole image the features are collected row wise to obtain accuracy in detection of defects in digital image.

3.2Elimination of High Frequency Components

After the extraction of feature vector the median value is used to eliminate the high frequency components in the digital image. Traditionally the texture components in the image have high frequency spectrum. So a defect is assumed to be in low frequency spectrum. The median values which are gathered from the feature vector row wise are used to form a new image which has only low frequency components which also includes the defected area. The image H is formed using the following equation

$$H = \begin{matrix} 1 & \text{if } f(x, y) \le \text{Median} \mid y = 1, 2, \ldots N \\ 0 & \text{otherwise} \end{matrix} \tag{6}$$

The above eq. states that f(x, y) is the original image and H is the output image which is obtained. The H is a binary image which is set to positive value when the intensity of the image f(x, y) is less than or equal to Median value of that particular row and H will result in zero value when the median value is less than f(x, y).The extracted image K is formed by using the following equation,

$$K = \begin{matrix} f(x, y) & \text{if } H(x, y) = 1 \\ 0 & \text{otherwise} \end{matrix} \tag{7}$$

The extracted image K is formed by having the binary image H. When the value of the binary image H is 1 then the corresponding intensity value of f(x, y) is applied for K otherwise the zero value is applied for K. The K extracted image consists of low frequency components including the defected area and eliminates the high frequency components. The idea behind gene-rating an extracted image K is the search operation for the defected area can only be done in low frequency areas where all the high frequency elements are made as zero. This technique in turn increases the speed of the search algorithm which is deployed for identifying the defected areas in the digital image.

3.3 **Identification Of Defected Area**

The extracted image K and the median value of each row of the original image f(x, y) is used for identifying the defected area. The defected area is identified sudden variation from the former pixel or from the median value. Every pixel in the row is checked individually with the former pixel and with the median value of that particular row. The pixel which has abrupt variation from the median value of about 60% or from the former pixel of about the same value is considered as a pixel in defected area. The comparison process excludes the pixels which have zero value in order to expedite defect detection algorithm. The defect detection algorithm is explained clearly with the help of the following equation,

$$DIM = \begin{matrix} 1 & \text{if } K(x, y) < \text{Median}(i)^{*}.6 \\ 1 & \text{if } K(x, y+1) < K(x, y)^{*}.6 \end{matrix} \quad y = 1 \text{ to } n \tag{8}$$

DIM is the resultant image which precisely highlights the defected area.

3.4 **Bilateral Filter for Restoration of Image**

The bilateral filter is a non-linear technique that can blur an image while respecting strong edges. Its ability to decompose an image into different scales without causing haloes after modification has made it ubiquitous in computational photography applications such as tone mapping, style transfer, relighting, and de noising. Its formulation is simple: each pixel is replaced by a weighted average of its neighbors. It depends only on two parameters that indicate the size and contrast of the features to preserve. It can be used in a non-iterative manner. This makes the parameters easy to set since their effect is not cumulative over several iterations. Bilateral filtering is an effective way to smooth an image while preserving its discontinuities An image at several different settings decomposes that image into large scale/ small-scale textures and features. These applications edit each component separately to adjust the tonal distribution, achieve photographic stylization, or match the adjusted image to the capacities of a display device. Data Fusion these applications use bilateral filtering to decompose several source images into components and then recombine them as a single output image that inherits selected visual properties from each of the source images .Applications 3D Fairing in this counterpart to image de noising, bilateral filtering applied to 3D meshes and point clouds smooth away noise in large areas and yet keeps all corners, seams, and edges sharp. The key idea is to extract the details of the flash image and combine them with the large-scale component of the no-flash picture. A variant of the bilateral filter performs this separation. The difficulty compared to images is that all three xyz coordinates are subject to noise, data are not regularly sampled, and the z coordinate is not a function of x and y unlike the pixel intensity.

IV **Results**

The proposed work is compared with the independent component analysis method and optimal gabor filter method for crack detection accuracy and elapsed time as shown in the table below

Figure 3.4 Restored Images (bilateral filter)

In the experiments, we adopted the performance identification of cracks. We tested the performance on some images and asked different users for the inspection of the images. The resultant images contain the identified cracks of the images. The statistics show the proposed algorithm is better than the other algorithms used. Apart from the accuracy there is no Error rate detected in the algorithm. Finally, in order to restore the image, bilateral filter are used which is restore the images in a cartoonist style.

Table 4.1 Comparison Analysis

Sl. No.	Name	Pixels In Defected Area	Proposed Algorithm		Independent Component Analysis Method		Optimal Gabor Filter Method	
			Defect detection Accuracy%	Elapsed Time (seconds)	Defect Detection Accuracy%	Elapsed Time (Seconds)	Defect Detection Accuracy%	Elapsed Time (Seconds)
1	Sample 1	650	89.38	0.1598	27.07	0.1611	41.84	0.5843
2	Sample 2	1087	94.84	0.1458	78.19	0.1604	44.43	0.5722
3	Sample 3	277	98.19	0.1574	15.52	0.2004	85.55	0.5014
4	Sample 4	941	95.11	0.1581	84.80	0.1987	94.47	0.5234

V CONCLUSION

The Algorithm has the capacity to be used in various types of images. This Algorithm is most suitable for the defects which have low frequency. This algorithm can be deployed in Auto-mated Visual inspection Systems. However to increase the efficiency of the algorithm to be suited for all forms of defects some future work has to be done.

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