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FAST AND EFFICIENT CRACK DETECTION FOR DIGITAL RE-ESTABLISHMENT OF OLDER PAINTINGS

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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. Finally, in order to restore the image bilateral filter are used. This methodology of detection and elimination of cracks in digitized paintings is shown to be very effective in preserving the edges also.

Keywords: Digital image processing, digitized paintings, crack detection, crack filling, top-hat transform methods, region growing algorithm, canny edge detection, bilateral filter.

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INTRODUCTION

Image processing techniques have recently been applied to analysis, preservation and restoration of artwork. 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.

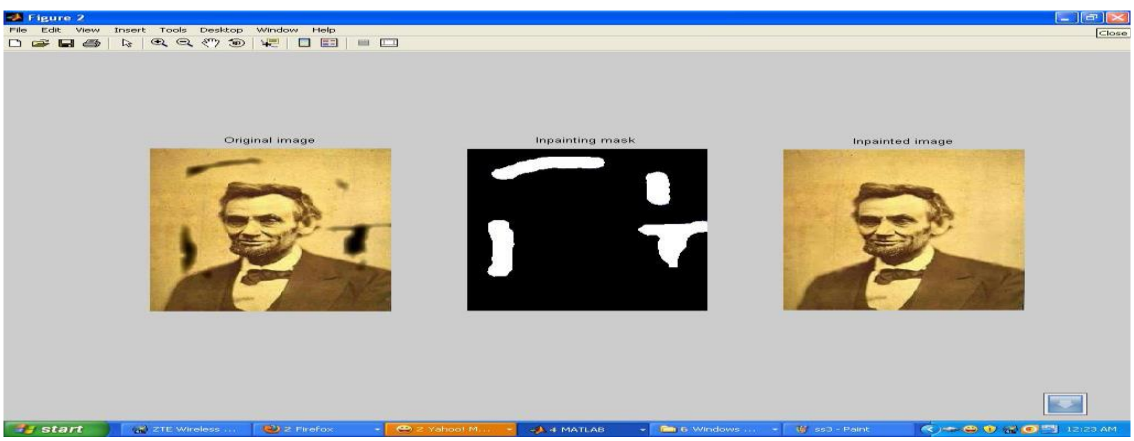

Figure (a) repaired color Image with Cracks with this approach

Proposed Work

A. 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 me-dian value is calculated for each row of the image. The mini-mum is represented with the equation.

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

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.

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

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,

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

The above equation states xm is the middle value of the par-ticular 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,

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

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 –

B . Elimination 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

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

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,

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

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.

C. ***Identification Of crack 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,

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

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

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. This text provides a graphical, intuitive introduction to bilateral filtering, a practical guide for efficient implementation and an overview of its numerous applications, as well as mathematical analysis. The bilateral filter has several qualities that explain its success: Its formulation is simple: each pixel is replaced by a weighted average of its neighbors. This aspect is important because it makes it easy to acquire intuition about its behavior, to adapt it to application-specific requirements, and to implement it. 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. It can be computed at interactive speed even on large images, thanks to efficient numerical schemes and even in real time if graphics hardware is available. It can be computed at interactive speed even on large images, Thanks to efficient numerical schemes and even in real time if graphics hardware is available .To conclude, bilateral filtering is an effective way to smooth an image while preserving its discontinuities bilateral filter has many applications, de noising this is the original, primary goal of the bilateral filter, where it found broad applications that include medical imaging, tracking, movie restoration, and more. We discuss a few of these, and present a useful extension known as the cross-bilateral filter. An image atseveral different settings decomposes that image into largescale/ 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. Other Applications new applications are emerging steadily in the literature; we highlight several new trends indicated by recently published papers. One of the first roles of bilateral filtering was image de noising. Later, the bilateral filter became popular in the computer graphics community because it is edge preserving, easy to understand and set up, and because efficient implementations were recently proposed. The bilateral filter has become a standard interactive tool for image de noising. For example, Adobe Photoshop provides a fast and simple bilateral filter variant under the name "surface blur". The bilateral filter preserves the object contours and produces sharp results. The surface blur tool is often used by portrait photographers to smooth skin while preserving sharp edges and details in the subject's eyes and mouth. Qualitatively, the bilateral filter represents an easy way to decompose an image into a cartoon-like component and a texture one. This cartoon-like image is the de noised image could be obtained by any simplifying filter. Bilateral filtering has been particularly successful as a tool for contrast management tasks such as detail enhancement or reduction range display .Bilateral filter decomposition to allow users to generate a high-dynamic-range image from a single low- dynamic-range one. They seek to reconstruct data in ove and under-exposed areas of the image .Techniques to produce satisfying pictures in low-light conditions by combining a flash and a no-flash photograph. Their work is motivated by the fact that, although the flash image has unpleasantly direct and hard-looking lighting, its signal-to noise ratio is higher than the no flash image. On the other side, the no-flash image has more pleasing and natural looking lighting, but its high frequencies are corrupted by noise and the camera may require a longer exposure time and increase the likelihood of blurring from an unsteady camera. 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. Bilateral filter on the GPU using the bilateral grid and achieved similar results on high definition videos.

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 (b) Restored Images (bilateral filter)

Figure (c) Restored Images (bilateral filter)

Figure (d) Restored Images (bilateral filter)

Figure (e) 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 above 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.1. Comparative Result 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

CONCLUSION

This paper presents crack detection Model .This model produces a crack map consisting of true cracks as illustrated in Fig. Further, we have employed a new filter to fill in the thick and thin cracks as shown in figs. Analysis of painting cracks has been a subject of interest for decades particularly for fine artwork conservators .It is believed that the existence of cracks on a painting does in a way relate to the structural support framework and physical impacts. In most cases, analysis is done manually by experts. A truly useful analysis is the classification of painting cracks into distinct patterns which can be used as a clue as to what really cause the cracks to form. A simple yet effective crack detection strategy has been implemented as a preliminary stage to segment the suspected cracks from the background. Several improvements can be made to this stage. An analysis on varnish layer is described in the paper to understand how it affects the color space of the old paintings and a technique for digital color restoration is proposed. The simulation performed on the number of paintings indicates that satisfactory results can be obtained if we have a clean painting with the similar color distribution as the old painting. For various applications, computer vision now plays an increasingly important role especially in quality.

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