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A Survey of Detection and Removal of Crack from Digital Painting

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Abstract -Ancient paintings are the cultural heritage for ones country and must be preserved. With the passage of time, painting gets damaged. The common deteriorations found in old paintings is Cracking. This paper discusses several techniques for restoration of old painting which are suffering from cracks. The approach includes detection of crack and removal of crack from digital painting. We can restore digital paintings using different image processing techniques. Normally we use low pass filters to detect cracks because cracks are low illuminated areas in paintings. But all low frequencies including brush strokes are passed by these filters, that's why to identify cracks properly they should be classified. Then we separate the thin brush strokes from the cracks by using method Semi-automatic crack separation and Discrimination on the basis of hue and saturation which have been detected as crack. We restore the image using local image information. For this purpose we use technique of order statistics filtering .Finally, using the idea of median filtering filling technique the cracks are filled.

Keywords: cracking, crack detection, crack removal, crack filling.

I. INTRODUCTION

Old painting which has great historic and artistic importance usually suffers from cracks or breaks[1]. These cracks can be caused by aging, drying, and mechanical factors [2]. Age cracks are result from nonuniform contraction in the wood-panel support or canvas of the painting, which stresses the layers of the painting. Drying cracks are caused by the evaporation of volatile paint components and the consequent shrinkage of the paint. Finally, mechanical cracks usually result from painting deformations due to external causes. The cracks in the paintings deteriorates the perceived image quality. One can use digital image processing techniques to detect and eliminate the cracks on digitized paintings. This "virtual" restoration can provide clues to art historians and the general public on how the painting was in its initial state, i.e., without the cracks. It can also be used as a nondestructive tool for the planning of the actual restoration. Other research areas which are closely related to crack removal is image inpainting which deals with the reconstruction of missing or damaged image areas by filling in information from the neighboring areas, and disocclusion. Methods developed in these areas assume that the regions where information has to be filled in are known. Methodology for detection and restoration of cracks on digitized paintings, which adapts a number of image processing and analysis tools is discussed.

The technique consists of the following stages:

i) crack detection
ii) separation of dark brush strokes which have been misidentified as cracks
iii) crack filling (interpolation)

Crack classification is a prerequisite step for restoration of old digital paintings. User interaction, most notably in the crack-detection stage, is required for optimal results.

II. LITERATURE SURVEY

Ioannis Giakoumis [2] et al. introduced an integrated methodology for the detection and removal of cracks on digitized paintings. The cracks were detected by thresholding the output of the morphological top-hat transform. then, the thin dark brush strokes are removed using either a median radial basis function neural network on hue and saturation data or a semi-automatic procedure based on region growing. Lastly ,crack filling using order statistics filters or controlled anisotropic diffusion were performed.

Rousopoulos .et al. introduced a paper named "Determination of the method of drawing of prehistoric wall paintings via original methods of pattern recognition and image analysis" [10]. In this paper a technique of construction of prehistoric painting was shown. They proposed a algorithm that perform preprocessing of the boundary of the figures showing within the painting, determines the patterns repetitions within the boundary of the represented components,

B. Cornelis et al [4] ,presented a new method for the virtual restoration of digitized paintings with special attention for the Ghent Altarpiece , a large polyptych panel painting of which very few digital reproductions exist. They achieved their

objective by detecting and digitally removing cracks. The detection of cracks were particularly difficult because of the varying content features in different parts of the polyptych. Three new detection methods they proposed and combined in order to detect cracks of different sizes as well as varying brightness. Semi-supervised clustering based post-processing were used to remove objects falsely labelled as cracks. For subsequent inpainting stage, a patch-based technique were applied to handle the noisy nature of the images and to increase the performance for crack removal. They demonstrated the usefulness of their method by means of a case study where the goal is to improve readability of the depiction of text in a book, present in one of the panels, in order to assist paleographers in its deciphering.

Sukhjeet Kaur [9] et al., developed a new algorithm that is nearest neighbour algorithm that can serve both the tasks of detecting and removing the cracks, so the quality of the wall painting images can be improved. For better improvement in the quality of digital wall painting ,another deformity is considered that is white spots which are detected as well as removed .The nearest neighbour algorithm is improved by increasing the contrast and saturation. This algorithm provide the more accurate result as compared to SIHF algorithm based on parameters that are Peak signal to noise ratio (PSNR) and mean squared error (MSE). This algorithm gives the more accurate results than the SIHF algorithm as it remove the more number of cracks and white spots.

III. CRACK DETECTION

Cracks can be categorized into two classes, bright cracks on a dark background or dark cracks on a bright background [4]. Different crack detection techniques are simple thresholding, line detectors and various morphological filters. Thresholding does not work well due to the noisy nature of the images and the presence of other crack like structures in the image. The varying quality of the images and the difficulty of detecting cracks in low contrast zones requires several pre processing steps. Different crack detection techniques that can be applied for the detection of both dark and bright cracks has been introduced.

Cracks usually have low luminance and, thus, can be considered as local intensity minima with rather elongated structural characteristics [3]. Therefore, a crack detector can be applied on the luminance component of an image and should be able to identify such minima. A crack-detection procedure based on the top-hat .

A. Top Hat Transform

Morphological filter most frequently used for detecting cracks within digitized art works is the top-hat transform. Top hat transform are of two types[5]. One is black top-hat transform and other is white top-hat transform.

) Black Top-Hat

The black top-hat transform used for detecting darker details on a lighter background. It is defined as the difference in pixel intensity between the closing of the original image by a specified structuring element and the original image itself.

It is defined by the equation

$bht = (g \bullet s) - g$

Here g is the original image and s is the structuring element. This transformation produces a greyscale image with the desired details enhanced.

ii) White Top-Hat

The white top-hat transform is used for detecting lighter details on a darker back-ground within grayscale images. This transform is defined as the difference in pixel intensity between the original image itself and the opening of the original image by a specified structuring element.

It is denoted by the equation

$wht = g - (g \circ s)$

Here g is the original image and s is the structuring element.This transformation produces a greyscale image with the desired details enhanced.

iii) Multiscale Top-Hat

Previous sections explain classical top-hat trans-forms. While these are popular and frequently used, they are not perfect. Paintings often contain details like brush strokes which are misinterpreted as cracks by these filters. To counteract this, as well as to detect cracks of varying sizes the multiscale morphological top-hat transform may be used . This transformation is executed by performing a series of classical top-hat transforms with structuring elements of various shapes and sizes. The resulting images, or crack maps, are then further processed to remove isolated groups of pixels and bridge pixel gaps.

Fig. 1 Image with cracks

Fig. 2 Cracks after Top-hat transform

IV. SEPERATION OF BRUSH STROKES FROM CRACKS

Brush strokes have almost the same luminance and thickness features as cracks[6]. The hair of a person is an example. Therefore, the top-hat transform may misclassify these dark brush strokes as cracks. It is very important to separate these brush strokes from the actual cracks, before the using of the crack filling procedure. Two methods are described below.

A. Semi-automatic crack separation

We can apply grassfire algorithm that checks recursively for unclassified pixels with value 1 in the 8-neighborhood of each crack pixel. At the end , the pixels in the binary image, which correspond to brush strokes that are not 8-connected to cracks will be removed.

B. Discrimination on the basis of hue and saturation

Hue of cracks ranges from 00 to 600 and hue of the dark brush strokes varies from 00 to 3600.Crack saturation ranges from 0.3 to 0.7 and brush stroke saturation ranges from 0 to 0.4. Great portion of the dark brush strokes can be separated from the cracks by classification using Median Radial Basis Function (MRBF) neural networks.

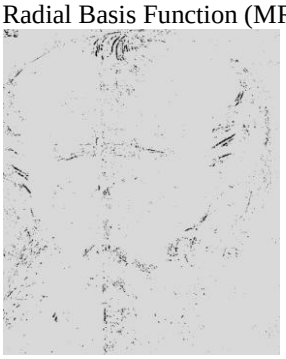

Fig. 3 Separated brush strokes after the application of the MRBF technique.

V. CRACK FILLING

After identifying cracks and separating misclassified brush strokes, finally we have to restore the image using local image information. For this purpose we use technique of order statistics filtering [6]. It is an efficient means to interpolate the cracks and is to apply median or other order statistics filters in their neighborhood. All filters are applied upon the cracks selectively.The core of the filter window passes through only the pixels of crack. If the filter window is huge, the pixels of crack within the window will lie outside and will be rejected. Thus, the pixels of crack will be assigned with the cost of one of the adjacent non crack pixels. A new filter known as a Modified Adaptive Median Filter (MAMF) can be used which works on each RGB channel independently only on the crack pixel locations. So quality of the content in other pixels is not affected .In addition to crack filling , this nonlinear filter, preserves the edges of the paintings. The standard median filter could be used for filling the crack. Problem with this method lies on its fixed window size .There could always be a possibility that crack pixel count in the local region may exceed the non crack pixel count. This may result in replacing a crack pixel by another crack pixel.

We therefore propose a modified version of an adaptive median filter where the window size surrounding the crack pixel can be varied.[6] This variation depends on the nature of pixels surrounding the crack pixels in the local region of window. It runs only over the crack pixels so that information in other pixel is kept intact. The size of the filter window surrounding each crack pixel is evaluated based on the number of crack pixels in the local region of the window. If the number of crack pixels in the local region exceeds some threshold value, the size of the window is expanded till it falls below the threshold. When the number crack pixels in the local region falls below this threshold level, the size of the window satisfying the condition is treated as the order n of the filter for processing the crack pixel under observation. *n* will be different for all crack pixels in the painting and is evaluated adaptively. Processing here refers to replacement of crack pixel under observation by the median of the local observations.It is equal to one, among the neighboring pixels.

The filled crack pixels are defined by:

f_i =med (A_{i-j}.....A_i.....A_{i+j}) .....(3)

Where A are the pixels in the local region of the window and $j = (n-l)/2$. For the color paintings the same process is used on three independent channels individually and then combined them to obtain crack filled color paintings.

VI. EXPERIMENTAL RESULTS

Fig.4 Input Image with Cracks

Fig.5 After Black-Hat and Selective Thresholding

Fig.6 Crack fillied final image

VII. CONCLUSSIONS

Cracks are detected by top-hat transform . This transform takes into account the foreground and background of image. The brush strokes, which are misidentified as cracks are parted either by an approach called semi-automatic approach or by an automatic method (MRBF networks).Process of crack interpolation is done by order statistics filters. The process has been implemented for the effective restoration of images in digital form and was found efficient by restoration experts.

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