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Detection & Removal of Cracks in Digitized Paintings Based on Image Processing

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Abstract

This paper presents of crack detection & removal techniques in digitized paintings. It is also used as a nondestructive tool for the actual restoration. The user must select an area on each crack that to be restored. The cracks are identified and detected by Gabor which is an integrated methodology for removal of cracks. First, we filter the selected crack image using 8 differently oriented Gabor filters. We describe an orientation-based feature extraction method to represent a crack network from sets of local orientation features. The resultant features are used for crack filling with median filter and weighted median filter. The methodology has been shown to perform very well on digitized paintings suffering from cracks.

1. Introduction

Every day, a huge amount of data is generated, thanks to the rapidly increasing size of digital storage space as well as the advent of the World Wide Web (WWW). Storage and retrieval of digital information is now possible at phenomenal speed, almost unimaginable just a decade ago. Information may contain pictorial data such as images or video sequences, as well as synthetic illustrations, diagrams, charts or computer aided graphics. Following a revolutionary trend, museums and art galleries are beginning to digitize their collections, not just to make them publicly available on the web, but also for internal use within the museums' or galleries' own environment. Digitizing the collection means providing a faster and more efficient way of recording what is available, thus giving a new dimension to methods of information retrieval within the environment itself. Instead of storing the information in a traditional manner, the ability to store it digitally opened the path for further manipulation of the technology, where digital preservation and restoration can play their part. Many paintings and artifacts were created centuries ago and are in need of preservation and restoration, to make sure that their physical appearance is maintained. Manual recording and detection of aging seem less efficient, given the increasing number of collections and electronic-based approaches seems to be the best choice.

Different types of materials are used for paintings and frames. For this use varnish, paint, glue, canvas, wood, metal, gilding and plaster. When both are used then it produces complex structure which can be easily damaged if knocked or dropped. Materials are damaged by different surrounding materials and they are also sensitive too. When there are changes in the heat and humidity then it changes appearance of images. Also when there is a change in environmental conditions then they also produce changes in the paintings and frames. Light and dirt also produce change in images [1]. Many paintings, especially old ones, suffer from breaks in the substrate, the paint, or the varnish. These patterns are usually called cracks or craquelure. This are produces due to no. of reasons like aging, drying, and mechanical factors. Age cracks can result from non-uniform contraction in the canvas or wood-panel support of the painting, which stresses the layers of the painting. Drying cracks are usually caused by the evaporation of volatile paint components and the consequent shrinkage of the paint. Finally, mechanical cracks result from painting deformations due to external causes, e.g. vibrations and impacts. So appearance of image get decreases image quality get reduces. The appearance of cracks on paintings deteriorates the perceived image quality [2]. So solution for this one can use digital image processing technique can be used in this process. Digital image processing techniques used to detect and eliminate the cracks on digitized paintings. So this type of processing images are used in museum, provide clues to art historians, and the general public on how the painting would look like in its initial state, i.e., without the cracks. Furthermore, it can be used as a non-destructive tool for the planning of the actual restoration [2].

Crack detection and removal have certain similarities with method proposed for detection and removal of scratches. This all information can be obtained by neighborhood pixels while filling the cracks on the images so that by using this transformation related to near pixels can fill the data related to that crack area. Other methods are also used for this. Other research areas that are closely related to crack removal include image inpainting which deals with the reconstruction of missing or damaged areas by filling in information from the neighboring areas [3].

The technique consist of following stages

- Crack detection
- Crack filling

This paper is organized as follows. Section 2 describes the proposed work. Cracks detection procedure is illustrated in section3. Methods for filling the cracks with image content from neighboring pixels are proposed in secion4. Conclusion and discussion follow.

2. Proposed work

The concept used in this is image processing techniques for analysis, preservation and restoration of artwork. The method proposed for detection and removal of cracks can be applied to remove scratches and other artifacts from motion picture film.[7]-[8] Such methods use information obtained over several adjacent frames. Another application deals with recovery of object parts that are hidden behind other objects within an image.

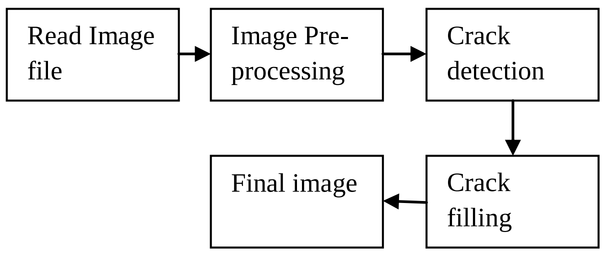


Fig. [2.1] Block diagram

The block diagram of proposed work shown in Fig.[2.1]. The approach used for crack detection & filling is mentioned below:

1. The digital image will be acquired from various databases.
2. Then image will be pre-processed to remove noise & adjust brightness.
3. Crack detection will be done by Gabor filter.
4. Crack filling will be made by using weighted median filter.
5. After filling crack we will get the restored image.

3. Crack detection

In most cases, cracks can be considered as being local minima with rather elongated structure [3]. In [5] cracks are identified by taking into account the fact that they have considerably darker grey levels compared to the background and are characterized by a uniform grey level. From a local point of view they also have a strong orientation tendency.

Gabor filters are band-pass filters which have both orientation-selective and frequency-selective properties as well as optimal joint-resolution in both spatial and frequency domains [6]. 2-d Gabor filter is a product of an elliptical Gaussian in any rotation and a complex exponential representing a sinusoidal plane wave. The sharpness of the filter is controlled on major and minor axis by γ and η. The equation below represents a Gabor filter in spatial domain:

Where

$$\psi(x,y;f_o,\theta) = \frac{f_o^2}{\pi\gamma\eta} e^{-\frac{f_o^2}{\gamma^2}x'^2 + \frac{f_o^2}{\eta^2}y'^2} e^{j2\pi f_o x'}$$

$$x' = xCos\theta + ySin\theta$$

$$y' = -xsin\theta + ycos\theta$$

Where f_o is the central frequency of the filter, θ is the rotation angle of both the Gaussian major axis and the plane wave, γ is the sharpness along the major axis and η is the sharpness along the minor axis (perpendicular to the wave). The aspect ratio of the Gaussian is $\lambda = \eta/\gamma$[10]

Fig. [3.1] Shows cracked image digitized paintings

Fig. [3.1] Cracked image

Fig.[3.2] illustrate the result of the real part of cracked digital image paintings

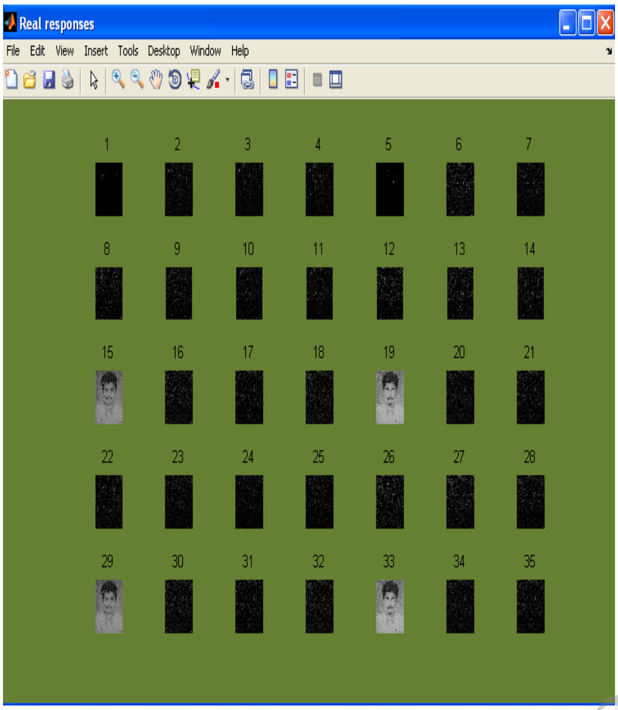


Fig.[3.2] Real part of cracked image paintings

Fig.[3.3] illustrate the result of the imaginary part of cracked digital image paintings

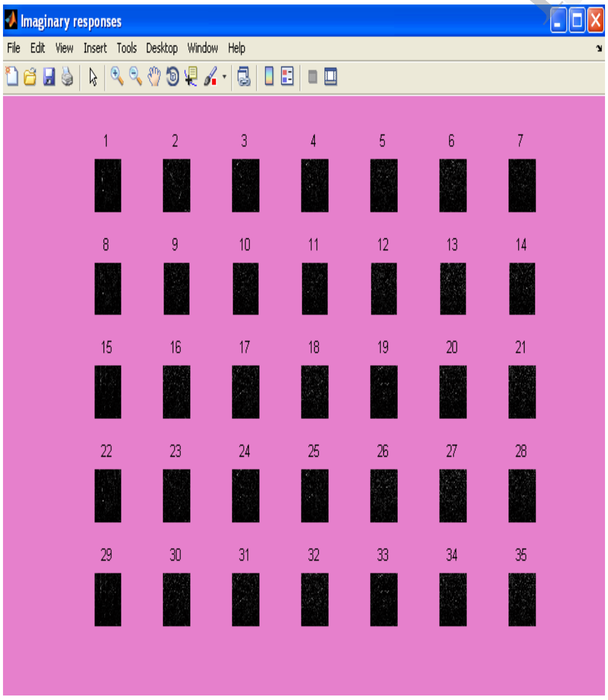


Fig.[3.3] result of the imaginary part of cracked digital image paintings

Fig.[3.4] illustrate the result of the magnitude of cracked digital image paintings

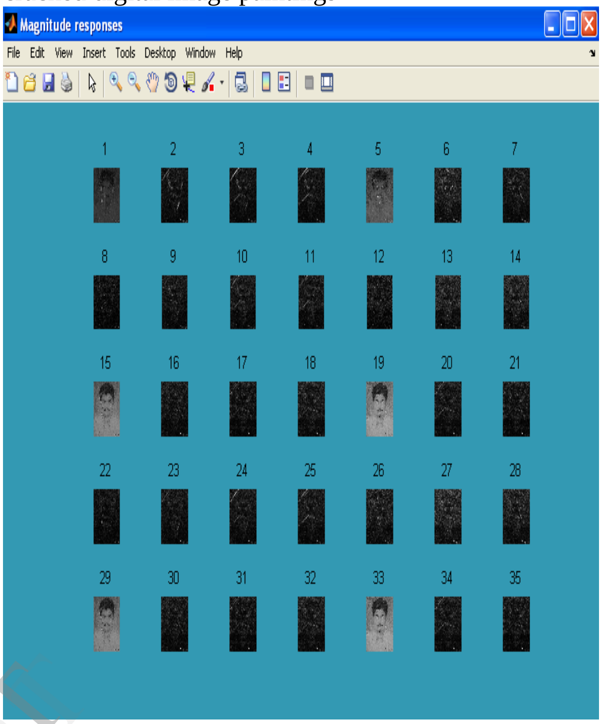


Fig.[3.4] result of the magnitude of cracked image

4. Crack filling

After identifying cracks the final task is to restore the image using local image information (i.e., information from neighboring pixels) to fill the cracks. Two methods utilizing median filter and weighted median filter are proposed for this purpose. The performance of the crack filling methods presented below was judged by visual inspection of the results.

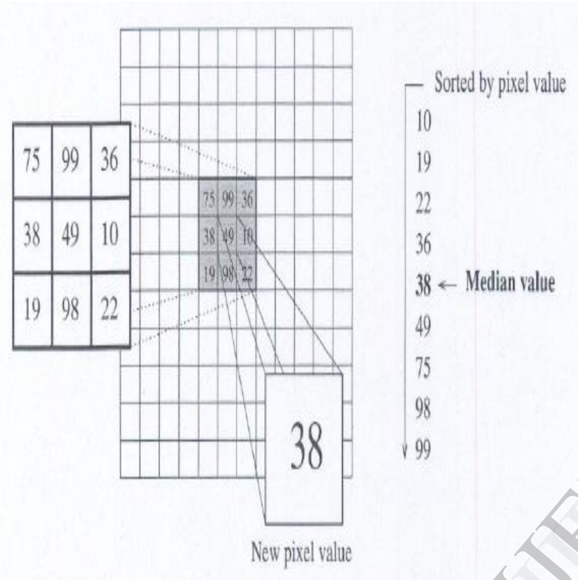
An effective way to interpolate the cracks is to apply filter in their neighborhood. All filters are selectively applied on the cracks, i.e., the center of the filter window traverses only the crack pixels. If the filter window is sufficiently large, the crack pixels within the window will be outliers and will be rejected. Thus, the crack pixel will be assigned the value of one of the neighboring non crack pixels.

The following filters can be used for this purpose.

- Median filter

A Median filter is a non-linear digital filter which is able to preserve sharp signal changes and is very effective in removing impulse noise. While linear filters have no ability to remove this type of noise without affecting the distinguishing characteristics of the signal. Median filter is applied on a 2-D mask of size NxN, where N is an odd number. For implementing the median filter, the pixels in the chosen mask need to be sorted in the ascending order then center pixel of the mask is replaced by the median pixel value from the sorted list. Fig. 4.1 illustrates the procedure. For the 3x3 mask with center pixel intensity of 49, the neighborhood pixels are sorted in the ascending order of their intensities. The center pixel intensity is replaced by the median value of the sorted list, which in this case is 38.

Example of median filter using 3X3 neighborhood



Fig[4.1] Median filter Illustration

- Weighted median filter

The weighted median (WM) filter was first introduced as a generalization of the standard median filter, where a nonnegative integer weight is assigned to each position in the filter window.

As shown in Fig.[4.2], the structure of a WM filter is quite similar to that of a linear FIR filter. For real-valued signals, WM filters can be defined in two different but equivalent ways. The first definition can be used in the common case of positive integer weights.

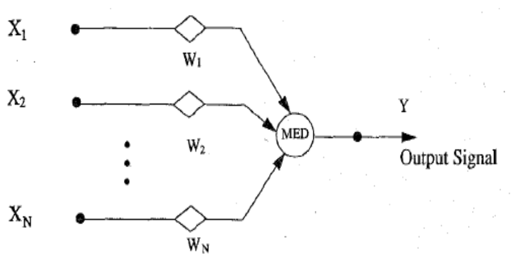


Fig.[4.2] Weighted median filter

Dejinition 4.1: For the discrete-time continuous-valued input vector $\boldsymbol{X} = [X_1, X_2, \ldots, X_N]$, the output Y of the WM filter of span N associated with the integer weights

$$w = [W_1, W_2, \ldots, W_N]$$

is given by

$Y = \mathrm{MED}[W_1 \diamond x1, w_2 \diamond x_2, \ldots, W_N \diamond x_N]$ (2.11)

where MED**[.]** denotes the median operation and $\diamond$ denotes duplication i.e.,

$K \diamond X = X, \ldots, X .\}$ ……… K times

This filtering procedure can be stated as follows: sort the samples inside the filter window, duplicate each sample X_i to the number of the corresponding weight W_i and choose median value from the new sequence[11].

5. Results

Gabor filter technique is applied on cracked images. The result is shown in Fig.5.1 in this first image is the original cracked images second image is the result of Gabor filter third image is the threshold output and fourth image is filled image. From this result we see that even hair size cracks are detected by this Gabor filter. Also using this Gabor filter dark brush strokes are not detected as a crack. This is advantage of Gabor filter.

Fig 5.1 Result of crack detection and crack filling.

The fig 5.2 shows input histogram of cracked image and output histogram of crack filled image and calculate histogram error.

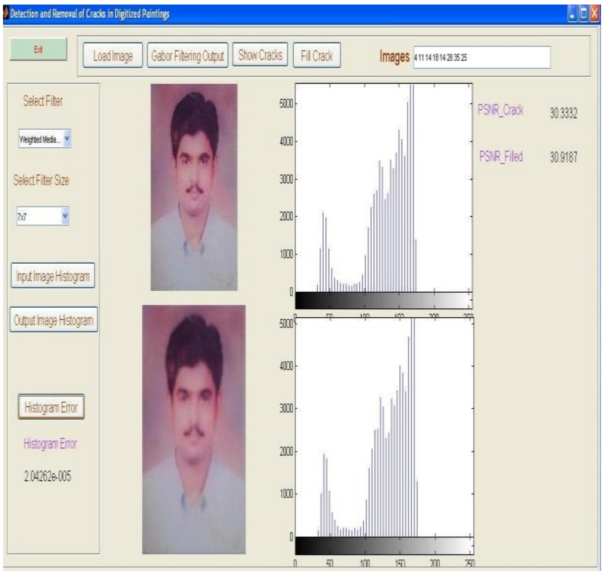


Fig 5.2 Result of crack detection and crack filling with histogram error

Following table shows the histogram error between cracked image and filled image

Sr. No.	Histogram error
Image1	$2.04262e^{-005}$
Image 2	$3.5642e^{-002}$

6. Conclusion

In this paper, we have represented an integrated strategy for crack detection in digitized paintings. Cracks are detected by using Gabor filter. Gabor features have shown to have beneficial properties in feature extraction for many computer vision tasks. Gabor filter has a good potential as far as detecting cracks are concerned since it provides the ability for scale-specific and multi-orientation detection.

The detected cracks are filled with weighted median filter. From histogram error we conclude that the cracks detected by Gabor filter are filled with weighted median filter

7. References

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