Automatic Crack Detection and Inpainting

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Abstract— *Image inpainting is the process of restoring the lost or damaged regions or modifying the image contents imperceptibly. It refers to the process of filling-in missing data in a designated region of the visual input. In this paper, the technique presented is for detection and removal of cracks from digitized paintings. Crack detection is done automatically by using bottom-hat morphological operation and median filtering is applied only on crack pixels for filling the cracks. We have found PSNR (peak signal to noise ratio)of the images in which the cracks are restored by applying median filtering only on crack pixels and compared the results with the other approach which restores crack by applying median filtering technique on whole crack image.*

Keywords- Digitized paintings, crack detection, crack filling, bottom-hat transform, crack restoration.

I. INTRODUCTION

Image inpainting is a method for repairing damaged pictures or removing unnecessary elements from pictures. It recovers the missing or corrupted parts of an image so that the reconstructed image looks natural. In real world, many people need a system to recover damaged photographs, designs, drawings, artworks etc. damage may be due to various reasons like scratches, overlaid text or graphics etc.

This system could enhance and return a good looking photograph using a technique called image inpainting. Image inpainting modify and fill the missing area in an image in an undetectable way, by an observer not familiar with the original image. The technique can be used to reconstruct image damage due to dirt, scratches, overlaid text etc.

We generally see paintings; especially old ones suffer from breaks in the substrate, the paint, or the varnish. These patterns are usually called cracks and can be caused by 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. The appearance of cracks on paintings deteriorates the image quality. However, one can use digital image processing techniques to detect and eliminate the cracks on digitized paintings. Such a "virtual" restoration can provide clues to art historians, museum curators and the general public on how the painting would look like in its initial state, i.e., without the cracks .

The concept of image inpainting was first introduced by Bertamio et al. [1]. The method was inspired by the real inpainting process of artists. The image smoothness information interpolated by the image Laplacian is propagated along the isophotes directions, which are estimated by the gradient of image rotated by 90 degrees.

In [2], they proposed a method for crack detection and restoration. Cracks usually have low luminance and can be considered as local intensity minima. The crack detection is based on top hat transform. Thresholding operation is required to separate out cracks from rest of the image. The result of the thresholding is a binary image marking the possible crack locations. For crack filling, different filtering techniques are used. The method in [3], manually select a point on the crack. Then it automatically tracks the crack. Once the selection has been done, the crack removal is automatic.

Exemplar Based method proposed by Criminisi et al. [4] used a best exemplar patch to propagate target patch including missing pixels. This technique uses an approach which combine structure propagation with texture synthesis and hence produced very good results. A morphological methodology (MAO) is used to identify cracks and a modified adaptive median filter (MAMF) is used to fill the cracks [5]. Authors in [6] used top-hat and bottom-hat transform for crack detection and the outputs of the crack detection stage are compared to know which transform gives better results. Speed and accuracy of a picture enhancement is compared using 8 pixel

neighbourhood with exemplar based Poisson and successive elimination method [7]. Vandalized and non-vandalized regions from the image are detected using template matching and Poisson image editing is used for inpainting of vandalized regions [8].

The method in this paper, obtains the crack map using bottom-hat morphological operation. Once the crack map is obtained, the cracks are filled by using median filter applied only on the crack pixels. Novelty of our algorithm is that the median filter is applied only on crack pixels so other pixels remain unaffected.

Paper is organized as follows. Section II describes how cracks are detected automatically. The block diagram description is given. After detection of cracks, how cracks are filled using an Inpainting technique that is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion and indicate future work.

II. DETECTION OF CRACKS

Cracks usually have low luminance and thus can be considered as local intensity minima with rather elongated structural characteristics. Therefore, a crack detector can be applied on the luminance component of an image. The block diagram represents a crack detection model as shown in Figure 1.The proposed crack detection model employs a bottom-hat transform followed by thresholding operation and Morphological Area opening process. Bottom-hat transform is a greyscale morphological filter which is defined as

$$BHT= Input\_image_{closing} - Input\_image$$

Where, $Input\_image_{closing}$ represents closing of an image. Here we have used 3 x 3 structuring element of type 'square'.
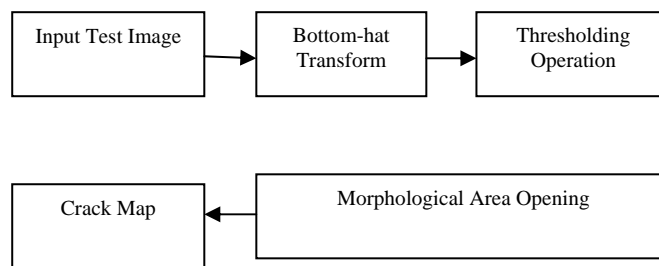

Figure 1. Crack Detection Model

A thresholding operation is performed on BHT operation to separate out crack pixels from background. Global thresholding technique is used to produce the binary image. Thereafter, the Morphological Area Opening process is accomplished to detect true cracks. Thus, the morphological area opening filter removes from the binary image, the components with area smaller than predefined parameter. After detection of cracks, our approach finds location of crack pixels and applies median filter of window size 7 x 7 only on the crack pixels considering neighbourhood of that crack only.

Three crack maps processed through the crack detection model are shown in Figures 2(b), 3(b) and 4(b), whereas Figures 2(a), 3(a) and 4(a) represents input crack image.
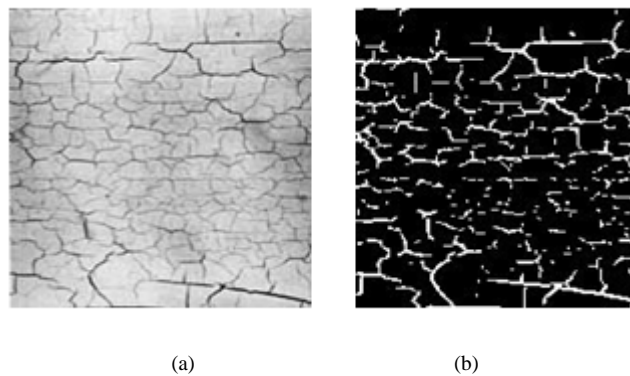

(a)   (b)

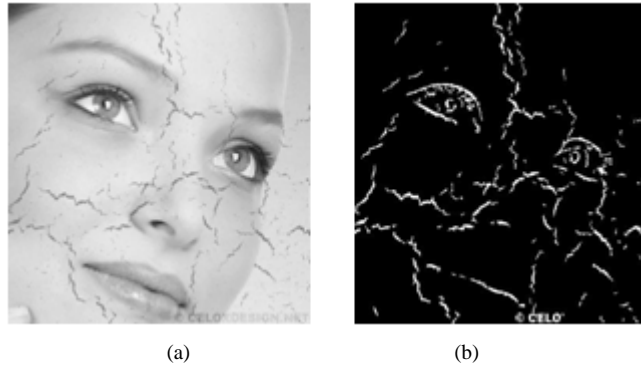Figure 2. (a) Cracked Painting   (b) Crack Map

Figure 3. (a) Cracked Painting   (b) Crack Map

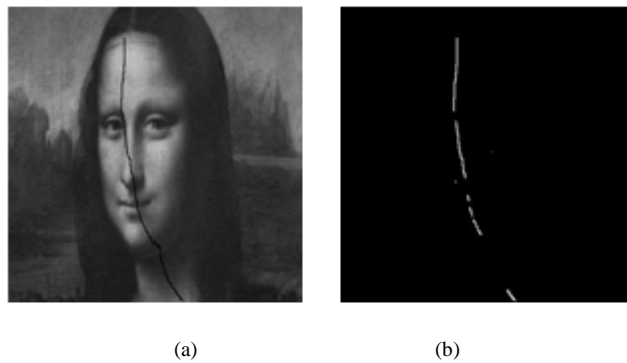Figure 4. (a) Cracked Painting   (b) Crack Map

III.   CRACK FILLING

Once a crack map is obtained, our next step is to fill the cracks based on local information from the region surrounding the crack pixel. We proposed a variational approach on median filtering which works only on crack pixel locations, so that quality of content in other pixels is not affected.

The standard median filter could be used for filling the crack, but the problem with this method is whole image blurring which reduces image quality. We therefore propose a variational approach of median filtering which works only on the crack pixels so that information in other pixel is kept intact.
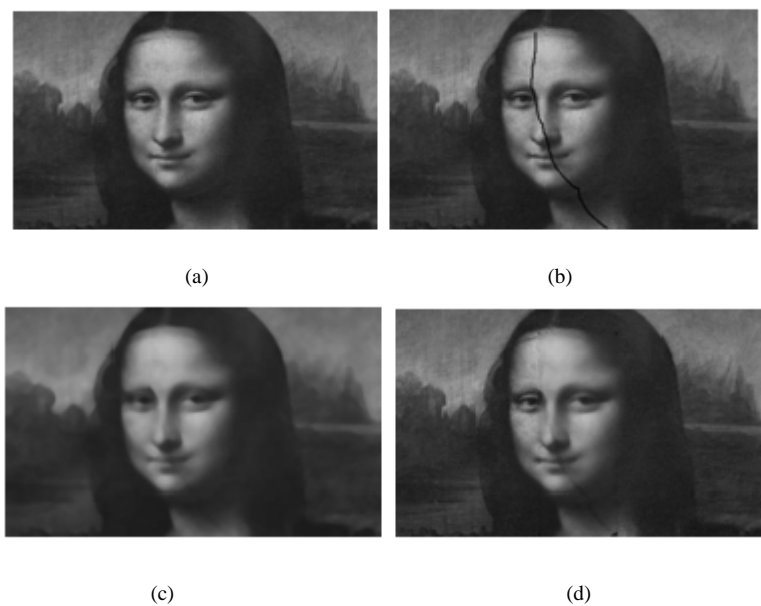
IV.   EXPERIMENTAL RESULTS

Figure 5. Crack Removal (a) Original image (b) Crack image (c) Crack restored by median filtering (d) Crack restored by applying median filter only on crack pixels

Figure 6. Crack Removal (a) Original image (b) Crack image (c) Crack restored by median filtering (d) Crack restored by applying median filter only on crack pixels

Figure 7. Crack Removal (a) Original image (b) Crack image (c) Crack restored by median filtering (d) Crack restored by applying median filter only on crack pixels
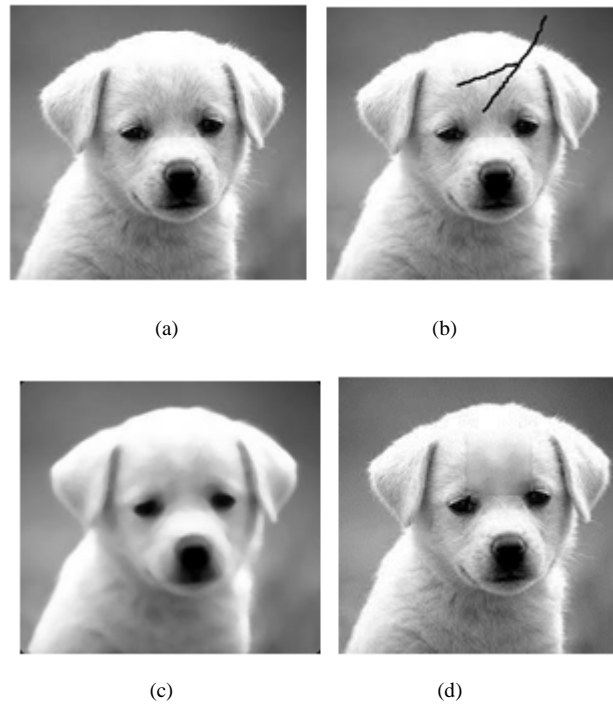
In figure, Figures 5, 6 and 7 (a) shows the original image. (b) is the crack image. (c) represents crack recovery by median filtering approach using 7 x 7 window. (d) shows the results obtained by proposed approach which considers only crack pixels and applies median filter only on those pixels.

From the above results, we conclude that directly applying median filter on the image results in blurring of the whole image, whereas the proposed approach works only on crack pixels so image blurring is less.

TABLE 1   PSNR VALUES OF ABOVE RESULTS

Figure	Median Filtering Approach	Proposed Approach (Applying median filter only on crack pixels)
Figure 5	18.16	20.11
Figure 6	11.40	16.80
Figure 7	19.33	21.34

Table 1 gives the comparisons between median filtering approach applied directly on the whole image and proposed approach that applies median filter only on crack pixels. Second column shows PSNR value obtained by median filtering approach and third column shows PSNR value obtained by proposed approach. From above results, we can conclude that use of median filter only on crack pixels improve the quality of an image.

V.   CONCLUSION AND FUTURE WORK

Image Inpainting is a technique to fill missing region or reconstruct damage area from an image. Inpainting technique may be automatic or manual. In Manual detection, users have to choose the region of interest to be inpainted, whereas automatic technique detects the region of interest automatically, without user interaction. In this paper, automatic Inpainting technique for crack restoration has been implemented. To virtually restore paintings, cracks have been detected and filled. Here, we have implemented a technique that works only on crack pixels to restore the crack. We also compare the results of these two methods and conclude that the proposed approach improves image quality.

Our future work aims at Inpainting of text regions in an image. Also, for crack restoration, different variants of median filter can be used to reduce whole image blurring.

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