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A Review Paper on Crack Detection and Restoration of Old Painting

Deepika Pagrotra[1], Navneet Kaur[2]

[1]M.Tech Scholar, Department of Computer Engineering, Punjabi University, Patiala

[2]Assistant Professor, Department of Computer Engineering, Punjabi University, Patiala

Abstract: ***Everyday digital image processing is used in all areas of science. With the help of image processing tools, various digital image processing can be applied for restoration of old painting. Ancient paintings are cultural heritage for ones country and must be preserved or restored. With the passage of time, painting gets Detroit. Cracking is one of the most common deteriorations found in old paintings. The paper presents the approach for restoration of old painting which are suffering from cracks. The approach includes crack detection and removal of the crack. This paper aims at the removal of the cracks from old paintings and to give its original view.***

Keywords: cracks, crack detection, crack filling, restoration, inpainting, texture synthesis

1. Introduction

Image processing techniques have recently been applied to analysis, preservation and restoration of artwork .Restoration can be done by using computer aided analysis and processing. Digitization of art works has become a common practice. For example, we can remove the signs of aging (such as cracks) from a digitized painting, visualize the effect of using different varnishes, discover patterns that would otherwise remain unnoticed or facilitate detection of forgeries.

Many paintings, especially old ones, suffer from breaks in the substrate, the paint, or the varnish. These patterns are usually called cracks. Cracking of the paint layers is one of the most common deteriorations in old paintings, arising inevitably with aging of the material. The level of this degradation is affected by many factors, from mechanical stress exposure to climate changes such as variations in temperature and humidity or pressurization (e.g., during air transport). Age cracks can result from no 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 painting. The appearance of cracks on paintings deteriorates the perceived image quality. Analysis of crack patterns can help preventing/reducing further degradations However, one can use digital image processing techniques to detect and eliminate the cracks on digitized paintings. 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. Furthermore, it can be used as a non destructive tool for the planning of the actual restoration. The user should manually select a point on each crack to be restored. Other research areas that are closely related to crack removal include image in painting which deals with the reconstruction of missing or damaged image areas by filling in information from the neighboring areas i.e., recovery of object parts that are hidden behind other objects within an image. The technique consists of the following stages:

- Crack detection.
- Crack filling (interpolation).

The various modules included are as follows:
1. Input module
2. Cracks Detection module
3. Crack filling module
4. Output module

a) ***Input module***: We provide the input image (cracked image) in this module.
b) ***Cracks detection module***: This module find the cracks in the cracked image with the use of surrounded pixels.
c) ***Cracks filling module***: This module fills the color by using cracks removal algorithm. The cracks will be filled by the surrounded pixel color.
d) ***Output module***: The output or the restored image will be produced by this module.

2. Crack Detection

Crack-like patterns or similar elongated structures appear in many applications of digital image processing and not only in those related to old paintings. Examples are medical images of blood vessels, images of fingerprints and satellite imagery of rivers and roads. Some common principles can be used in the extraction of all these different crack-like patterns in order to separate them from the rest of the image. This means that we can make use of the accumulated knowledge in digital image processing and a lot of existing algorithms for the detection of crack-like patterns.

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 and should be able to identify such minima. A crack-detection procedure based on the top-hat and bottom-hat transform is proposed in this paper. The major part is the structuring element and it is a shape, used to probe or interact with a given image, with the purpose of drawing conclusions on how this shape fits or misses the shapes in the image. It is typically used in morphological operations, such as dilation, erosion, opening, and closing, as well as the hit-or-miss transform. Many of these approaches are based on different types of "thresholding" (e.g. setting a threshold on the grey values and detecting as a dark crack all the locations where the pixel intensity is below the chosen threshold). Specific methods for crack detection in old paintings were reported. They were based on a semi-automatic crack detection procedure, where users need to specify a location believed to belong to a crack network. Two morphological operations are mainly used for crack detection: Top-hat and Bottom-hat transform followed by selective thresholding.

a) Top-hat Transform

This can be used to eliminate particular features from an image. The general method is to applying opening or closing to an image followed by a subtraction with the original image with the order depending on the type of the feature. While in many situations it is problematic to get a representation of the background, in most cases it is easier to get a rough estimate of the features in the image. So to get the background, you remove the feature from the image. If you now subtract this background image with the feature removed from the original image you will only get the desired feature. The order of the subtraction operation depends once more on what you consider to be the background and what the foreground. Top hat transform can be implemented by the following equation: THT = $f(x) - f_{opening}(x)$, where f(x) = original image and $f_{opening}(x)$ represents the open of image $f(x)$

b) *Bottom-hat transform*:

The detection process involves bottom-hat transform (BHT) over luminance component of the image to detect dark pixels, given by:

BHT = $f_{closing}(x) - f(x)$, where $f(x)$ = original image and $f_{closing}(x)$ represents the close of the image f(x).

c) *Selective Thresholding*:

Since the pixels representing cracks have high gray values we set a suitable threshold to distinguish the cracks from the rest of the image. A thresholding operation is required to separate the cracks from the rest of the image. A threshold can be chosen by trial and error procedure that is inspecting its effect on resulting crack maps.

3. Crack Filling

After detecting the crack pattern, we need to fill in the missing regions**.** Cracks can be filled by two approaches:

a) *Inpainting*

It is called inpainting as literal terms for the process of painting in holes or cracks in an artwork making use of information about the local neighborhood of a pixel only, and making use of global statistics to aid the local statistics inpainting is used explicitly for filling holes in an image. The problem in inpainting is posed as follows: Given an area to be inpainted, filling in the missing areas or modifying the damaged one in a non-detectable way for an observer not familiar with the original image. Crack inpainting methods reported are mostly pixel-based, employing principles like order statistics filtering and controlled anisotropic diffusion. Both are implemented on each RGB channel independently and affect only those pixels which belong to cracks. Therefore, provided that the identified crack pixels are indeed crack pixels, the filling procedure does not affect the useful content of the image. The performance of the crack filling methods is judged by visual inspection of the results.

b) *Texture synthesis*

According to Wikipedia, texture synthesis is the process of algorithmically construction a large digital image from a small digit sample by taking advantage of its structural content. Texture synthesis draws from natural or artificial textures to create a textured pattern. Texture synthesis or hole filling, in which the synthesized region must look like the surrounding texture**.** There are two basic methods for texture synthesis:-

Pixel based and Patch based texture synthesis:

Pixel based is one of the simplest and most successful general texture synthesis algorithms. They typically synthesize a texture in scan-line order by finding and copying pixels with the most similar local neighborhood as the synthetic texture. They are typically done with some form of Approximate Nearest neighbor method since the exhaustive search for the best pixel is somewhat slow.

Patch-based texture synthesis creates a new texture by copying and stitching together textures at various offsets. The idea is to transfer small and well chosen image parts from undamaged regions of the image to the damaged positions, such that they fit well with the surrounding context. In actual process, the *target* denotes partially or fully damaged image patch and *source* denotes the patch that will be transferred (as a whole or in part) to the damaged position. These algorithms tend to be more effective and faster than pixel-based texture synthesis methods.

4. Conclusion

This paper presented an independent study of techniques. Morphological operations; top hat and bottom hat transform have been discussed for detection of cracks. Top hat transform takes into account the foreground and background of image, and bottom hat involves applying bottom hat transform over the dark pixels. Inpainting and texture based technique for crack filling were also studied. Inpainting is a pixel-based technique that uses local pixel values for filling cracks. the synthesized region must look like the surrounding texture. In texture synthesis, the synthesized region must look like the surrounding texture. Texture synthesis uses pixel based as well as patch based approach.

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Authors Profile

Deepika Pagrotra, M.Tech Scholar, Department of Computer Engineering, Punjabi University, Patiala, Punjab, India

Navneet Kaur, Assistant Professor, Department of Computer Engineering, Punjabi University, Patiala, Punjab, India