Image Processing Methods Performance for Digital Re-establishment of Older Paintings

Hulas Ram[1], Minu Choudhary[2]

[1]Rungta College of Engineering and Technology, Kohka Kurud Road, Bhilai, Chhattisgarh, India
[2]Rungta College of Engineering and Technology, Kohka Kurud Road, Bhilai, Chhattisgarh, India

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 top-hat transform 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

1. 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. Top-hat transform is proposed in this paper for crack Detection procedure. The top-hat transform is filter defined as $y(x) = f(x) – fn\ B(x)$ where $fn\ B(x)$ is the opening of the function. The aim of the Artiste project was to provide access across museum collections using metadata as well as content-based retrieval of image data.

Figure (a): Original Image with Cracks (Detail)

Figure (b): Top Hat Transform Image


Figure (c): Crack Map (Region Growing Algorithm)

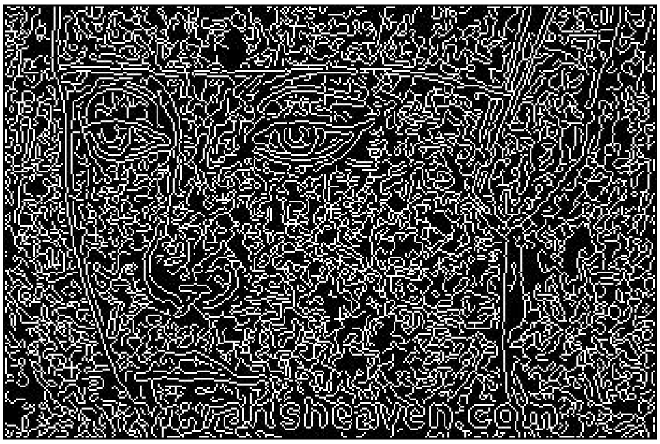

Figure (d): Top Hat Transform Image Edge (Canny Edge Detection)

Figure (e): Restored Image (Bilateral Filter)

Figure (f): Restored Image Edge (Canny Edge Detection)

2. A Crack Detection Model

Cracks normally contain low luminance and, hence it is considered as local intensity minima. Therefore, a crack detector is applied on the luminance component of an image and should be able to identify such minima. Top-hat transform is proposed in this paper for crack detection procedure. The top-hat transform is filter defined as y(x) = f(x) – fn B(x) (1) where fn B(x) is the opening of the function f(x) with the structuring set, defined as n B = B BB---- B (n times) (2) In the previous equation, denotes the dilation operation. The final structuring set is evaluated only once using (2) and is used subsequently in the opening operation of (1). The opening of a function is a low-pass nonlinear filters that erases all local maxima for which the structuring element cannot fit. Hence, the digital picture contains only those local maxima and no background at all. Since cracks are local minima rather than local maxima, the top-hat transform should be applied on the inverse luminance image. The output of the detection procedure can be controlled by selecting the suitable values for the user can control the result of the crack-detection procedure by choosing appropriate values for the following quantities:

- Structuring element type;
- Structuring element size
- Number of dilations in equation

These quantities produce an effect on the size of the resultant structuring element and must be selected according to the broadness of the cracks to be detected. The top-hat transform produces a grayscale resultant image where pixels with a high grey value are potential crack or crack-like elements. Therefore, a thresholding operation on resultant image is required to separate cracks from the rest of the image. The number of image pixels which are separated as cracks decreases as the threshold value increases. Hence certain cracks, especially in dark image areas where the local minimum condition may not be achieved, can remain undetected. Therefore it is better to select the threshold value so that some cracks remain undetected than to select a threshold that would result in the detection of all cracks but will also falsely identify as cracks, and subsequently modify, other image structures [2].

- The cracks are identified by thresholding the output of the top-hat transform.
- In mathematical morphology and digital image processing, top-hat transform is an operation that extracts small elements and details from given images. There exist two types of top-hat transform: The *white top-hat transform* is defined as the difference between the input image and its opening by some structuring element; the *black top-hat transform* is defined dually as the difference between the closing and the input image. Top-hat transforms are used for various image processing tasks, such as feature extraction, background equalization, image enhancement, and others.

- *Mathematical definitions*

Let $f : E \mapsto R$ be a gray scale image, mapping points from a Euclidean space or discrete grid *E* (such as R^2 or Z^2) into the real line. Let $b(x)$ be a gray scale structuring element. Then, the white top-hat transform of *f* is given by:

$T_w(f) = f - f \circ b$, where $\circ$ denotes the opening operation. The black top-hat transform of *f* is given by:

$T_b(f) = f \bullet b - f$, where $\bullet$ is the closing operation.

3. Region Growing Algorithm for Crack Separation

An easy user friendly technique for these cracks from breaks is to apply a region growing algorithm on the threshold result of the top-hat transform, starting from pixels (seeds) on the actual cracks. The pixels are chosen by the user in an interactive way. At least one seed per connected crack element should be selected. In the similar way, the user can apply the method on the breaks, if this is more appropriate. The growth mechanism checks recursively for unclassified pixels with value 1 in the 8-neighborhood of each crack pixel. At last phase of this procedure, the pixels in the binary digital picture, which correspond to breaks that are not 8-connected to cracks, will be cleared. An example is shown here. Cracks are normally considered as darker than the background and that they are characterized by a uniform gray level, tracking is accomplished on the basis of two main features: absolute gray level and crack uniformity. Once the system knows some pixels belong to a crack, it assigns to the crack new pixels if their gray levels lie in a given range and do not differ significantly from those of the pixels already classified as belonging to the crack [3].

4. Canny Edge Detection for Detection of Edges in Image

The Canny edge detector is widely used in computer vision to locate sharp intensity changes and to find object boundaries in an image .The Canny edge detector classifies a pixel as an edge if the gradient magnitude of the pixel is larger than those of pixels at both its sides in the direction of maximum intensity change .Edge detection is one of the fundamental operations in computer vision with numerous approaches to it. Among the edge detection methods proposed so far the Canny edge detector is the most rigorously defined operator and is widely used The popularity of the Canny edge detector can be attributed to its optimality according to the three criteria of good detection good localization and single response to an edge It also has a rather simple approximate implementation .The purpose of edge detection in general is to significantly reduce the amount of data in an image, 1. Detection: The probability of detecting real edge points should be maximized while the probability of falsely detecting non-edge points should be minimized. This corresponds to maximizing the signal-to-noise ratio.2. Localization: The detected edges should be as close as possible to the real edges.3. Number of responses: One real edge should not result in more than one detected edge (one can argue that this is implicitly included in the first requirement).The edge-pixels remaining after the non-maximum suppression step are (still) marked with their strength pixel-by-pixel. Many of these will probably be true edges in the image, but some may be caused by noise or color variations for instance due to rough surfaces. The simplest way to discern between these would be to use a threshold, so that only edges stronger that a certain value would be preserved. The Canny edge detection algorithm uses double thresholding. Edge pixels stronger than the high threshold are marked as strong; edge pixels weaker than the low threshold are suppressed and edge pixels between the two thresholds are marked as weak [18].

5. 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 at several different settings decomposes that image into large-scale/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 lowdynamic-range one. They seek to reconstruct data in over- 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.

6. Results

- The top-hat transform generates an output image where pixels with a large grey value are potential crack or crack-like elements. Therefore, a thresholding operation is required to separate cracks from the rest of the image.
- 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 breaks which identified as cracks are separated using a region growing algorithm.
- The edges of images are identifying by the help of canny edge detection.
- Finally, in order to restore the image, bilateral filter are used which is restore the images in a cartoonist style.

7. Conclusion and Future Work

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 evaluation of art images, as a tool for art analysis, and virtual enhancement, as well as restoration and image retrieval. Steps can be taken in the future to improve and allow other possible applications. This paper presents crack detection and restoration of image in various formats in only windows operating system for crack detection and restoration of image in other operating system is a limitation of the project [19].

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[3] Mr. Sachin V. Solanki1 and Prof. Mrs. A. R. Mahajan2 PG Department of CSE, G. H. Raisoni College of Engineering, Nagpur, India hisachinsolanki@yahoo.co.in

[4] Ioannis Giakoumis, Nikos Nikolaidis, Ioannis Pitas Department of Informatics Aristotle University of Thessaloniki 54124 Thessaloniki, Greece tel/fax: +302310996304,e-mail: fnikolaid,pitasg@zeus.csd.auth.gr

[5] F.S. Abas and K. Martinez Intelligence, Agents, Multimedia Group, Department of Electronics and Computer Science, University of Southampton, United Kingdom, S017 1BJ.

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Author Profiles

Hulas Ram received the M.C.A. degree from Rungta College of Engineering & Technology, Bhilai, in 2009, and pursuing M.Tech in Computer Technology from Rungta College of Engineering and Technology, Bhilai, in 2011. His current research interest is in Image Processing System for Digital Restoration of Digitized Picture.

Minu Choudhary is Reader in Rungta College of Engineering & Technology (Department Information Technology), Bhilai, India. Her area of interest is Image Processing.