Review Paper on Automatic Scratch Lines Noise Removal from Video

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Abstract— The digitalization and transfer of older films into high definition (HD) formats imply that high quality of restoration is necessary. Now a day's Digital film restoration is an area under discussion of increasing interest to researchers and film archives alike. Old films, including cultural heritage masterpieces, are being digitally premastered and transferred into novel, higher quality formats and distributed through various means such as DVD, Blu-ray or HD pictures. Detection of Line scratches in old movies is a particularly difficult problem due to the variable spatiotemporal characteristics of this deficiency. Some of the main problems consist of sensitivity to noise and texture, and fake detections due to thin vertical structures belonging to the scene. Automatic finding of image damaged regions is the key to automatic video image inpainting. Vertical scratches are the common damages in the old film. As the film is a collection of number of frames arrayed together to produce a motion sequence hence it becomes a lengthy and tedious work to process any video format in any manner. Normally if any scratch or noise generated on films it remains as it is on many frames in sequence in film which can be benefitted by the removal process by initially checking noise area on earlier slide. Hence proposed system is aimed at designing and developing of line scratches detection from old films and remove it.

Keywords— Scratch detection, old film restorations, image inpainting

I. INTRODUCTION

In recent times, digital image inpainting has become a hot field in digital image processing. Digital inpainting techniques have found broad applications in digital restoration of ancient paintings for preservation purposes, restoration of old films and photographs. However, most repair work require professional to determine manually repaired area, or processes all pixels indiscriminately, so that these inpainting techniques cannot be used in huge quantity image processing and video repair. The key to solve this problem is automatic detection of image damaged regions. Base on these, in proposed system, system focus on the common vertical scratches in the old films and talk about the scratch detection technology before the digital inpainting, which is the origin for the automatic restoration.

It has more than ten years on researching detection of vertical scratches. It is emerged many detection methods during this age. The last century in the late nineties, Kokaram first started to study systematically line scratches, and presented a mathematical model of vertical scratches and distorted image. This method can sense vertical scratches 10 single frame image. After preprocessing, median filtering, Hough transform, Bayesian algorithm, it can determine really scratch position. However, the algorithm needs to adjust the threshold value for dissimilar images. It cannot differentiate between true vertical scratches and vertical objects in image. On the other hand, completing time of this algorithm is very lengthy, which is not useful to real-time processing and cannot handle a large number of successive video frames. In view of this, Joyeux proposed a Space Time Decision Method to answer this difficulty, but the algorithm was not entirely linear scratches services and was not widely adopted. V. Bruni thought that the mathematical model of vertical scratches is not truly he improved the scratch mathematical model of Kokaram, and proposed a novel model of vertical scratches. The model works fine to a single image, but it is time consuming, also it cannot distinguish between true vertical scratches and vertical objects in image. In 2008, V. Bruni tried to detect scratches in the color image. Earlier than detection algorithm, they used Shannon sampling theorem to sample vertically image in order to eliminate red component, and they applied the scratch detection method in gray scale images to detect vertical scratches. Although this technique sometimes presented false alarm, it provided a direction to vertical scratches detection and restoration work in color images.

A number of the most frequent defects in films include dust/dirt, blotches, flicker and line scratches. Here, we think about the last defect, the line scratch, regularly caused by a scratch to the physical film. These line scratches become visible as thin bright or dark lines which are roughly straight and vertical. These defects also present the singular characteristic of temporal persistence, meaning that they remain in the same or a similar spatial position for a number of frames. Therefore, line scratch detection algorithms must be specially adapted to this defect. On the other hand, these characteristics are very variable, making line scratch detection and restoration a particularly complicated challenge. For instance, in some cases, the scratch is semi-transparent, so that some of the original image information is still accessible, whereas in others all the information of original image is removed. Also, scratches are not necessarily totally straight and vertical, and their shape may in fact vary from frame to frame. Finally, although scratches can often be static, they may also travel with any type of motion.
In this paper, we firstly focus on the common vertical scratches in the old films and talk about the scratch detection technology before the digital inpainting, which is nothing but base for the automatic restoration. We propose a vertical scratch detection algorithm based on edge detection. Secondly in this paper A novel non-linear interpolation method is proposed, both of information in and between the frames are used to create the interpolation polynomial. Since the non-linear scheme is more suitable for human visualization and interpolation method is always quick, our method shows its effectiveness in video inpainting. We make a scratch detection before the interpolation.

II. PROBLEM FORMULATION

Figure 1: Binary detection image from “Laurel and Hardy”. White pixels are detected and black pixels are not.

III. PROPOSED METHODOLOGY

The proposed methodology contains two main stages where first is to detect the noise or the scratches in the frame and second is to remove the scratches.

A. DETECTION OF THE SCRATCHES

After cautiously checking and analysis of the existing number of common vertical scratch detection technique, we found that most Algorithms are not easy to take into account the simplicity of the algorithm, integrity of the algorithm and efficiency of the algorithm at the same time. Based on these, we present a scratch detection technology based on edge detection.

The key idea of this method is as follows:
• Firstly obtaining Gray scale image form input image.
• To detect image edges use sobel edge detection. During the detection, we use the operator which has the largest response to the vertical edge in sobel operator;
• canny operator uses to detect edges further;
• Detecting the vertical lines in the image through probabilistic Hough transform;
• The true locations of the vertical lines scratches obtaining through morphology and width constraints.

The Proposed process flowchart of our method is shown in Figure.2.

The main steps of our algorithm are as follows:
1) Transforming input image \( f(i,j) \) into gray scale image \( I \).

We use the formula as follows:
\[
I = \max(R, G, B)
\]  

\(R, G, B\) is the red, green, and blue color channels of input image \( f(i, j) \), respectively.

2) Sobel edge detection

The Sobel operator, sometimes called as Sobel filter or Sobel–Feldman operator. Sobel operator is used for computing the gradient approximation of image brightness function also it is a discrete difference operator. As per the direction of detection, the edge detection methods can be classified into two types which is expressse

\[
G_x = \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix} \ast f
\]

\[
G_y = \begin{bmatrix} 0 & 0 & 1 \\ 2 & 0 & 2 \\ 1 & -1 \end{bmatrix} \ast f
\]

Where \( f \) is original image, \( G_x \) is received by the horizontal edge detection, \( G_y \) is received by the vertical edge detection. In this paper, we mainly focus on vertical scratches so that we use the equation (2) as sobel edge detection. As the Sobel operator also merely detect false edges and easily form the
non-closed area, so it is essential to further detection and location. We use an optimal ladder-type detection algorithm, canny edge detection, to further processing.

3) Canny edge detection

Canny operator was proposed by Canny which is a multiscale edge detection operator. Basic steps are as follows:

i) In order to remove noise use Gaussian filter to smooth the image

We select the formula for Gaussian function and the smoothing as follows:

\[ G(x,y) = \frac{1}{2\pi\sigma^2} \exp \left( -\frac{x^2+y^2}{2\sigma^2} \right) \]  

\[ f'(x,y) = f(x,y) * G(x,y) \]  

Where \( G(x,y) \) is the Gaussian function, \( \sigma \) is the distribution parameter, \((x, y)\) is input image, and \((x,y)\) is smoothing image.

ii) Computing the magnitude and the direction of gradient.

We use the following equations to compute the Gradient magnitude and the Gradient direction.

\[ p_1(a,b) = f'(x,y) * \begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix} \]  

\[ p_2(a,b) = f'(x,y) * \begin{bmatrix} -1 & 1 \\ 1 & -1 \end{bmatrix} \]  

\[ p(a,b) = \sqrt{p_1^2(a,b) + p_2^2(a,b)} \]  

\[ \theta_p = \tan^{-1} \frac{p_2(a,b)}{p_1(a,b)} \]  

Where \( p_1(a,b) \) and \( p_2(a,b) \) are the results of the first difference along the horizontal and vertical directions. \( p(a,b) \) is the magnitude of the gradient, \( \theta_p \) is the direction of the gradient.

iii) Suppressing the magnitude of the gradient by the non-maxima.

iv) Detecting and connecting the edges.

4) Detecting the vertical lines through probabilistic Hough transform

For improving the speed of the algorithm, we have to use Hough transform function. The Hough transform function detects and marks the straight lines in the form of returning line segmentation. When it exits vertical scratches being of different lengths in the damaged image, if we use the function method, select the proper threshold parameters, we able to detect and mark the short vertical scratch.

5) Obtaining the real scratches by Morphological processing and the constraints of width

The vertical lines have been detected by probabilistic Hough transform. It also includes the natural vertical objects between these lines, we must exclude them to obtain the real scratches. In our algorithm, we use the following steps:

i) The opening operation in Morphological processing.

Formula (10) and (11) show the erosion and dilation operations of opening operation, respectively.

\[ f \ominus B = \{ z | (f \cap B)_z \subseteq f \} \]  

\[ f \oplus B = \{ z | (f \cup B)_z \cap f \neq \emptyset \} \]  

Where \( f \) is the image after probabilistic Hough transform. \( B \) is structural elements, here we take a rectangular which size is 3x3. \( z \) is the points in \( B \) which contains \( f \). The erosion image \( f' \) is obtained by translating \( z \). \( z' \) is the points in \( B \) which contains \( f' \), the dilation image \( g \) is obtained by translating \( f' \).

ii) Excluding the false scratches by setting the width threshold of the scratches.

This approach is based on the fact that scratch is generally 3 to 10 pixels wide. After opening operation, the adjacent border of the natural vertical objects in the image \( g \), such as frame border, will be connected into a region which with is larger than scratch's. Then if we set the appropriate width range, we can remove too wide and too smaller vertical line and eventually obtain the location of the real scratches.

B. REMOVAL OF SCRATCHES

After the scratch detection, we find the location of scratch. Then proper pixels should be found to construct interpolation formulation. For digital image restoration, neighbor pixels around the scratch contributes more than pixels far away. In the case of digital video inpainting, neighbor frames also contain important information. The temporal correlation of the frames and randomness of the scratch make it possible to find the missing data in the neighbor frames. In this paper, we not only consider the spatial continuity but also the time coherency. We first use the information of frames nearby. We choose four frames before and after the current frame, so there are eight correlated frames altogether. For every missing pixel within the scratch, we can find a pixel in the same location of the correlated frame. Then Linear interpolation can be constructed using these pixels of eight frames.

Let \( F_c \) denote the current frame at \( t \) moment, then the four frames before it can be denoted as \( F_{c-1}, F_{c-2}, F_{c-3}, F_{c-4} \) and frames after are \( F_{c+1}, F_{c+2}, F_{c+3}, F_{c+4} \)

Suppose \( F_c \) \((x, y)\) is a pixel within scratch, then it can be estimated by Linear interpolation using
Where $t_i$ (i=0...7) are moments of interpolated frames. Sometimes we will encounter the situation that a scratch appears a long time at the same location. To this kind of circumstance, spacial information is taken into considered. Unlike some local interpolation method, global strategy is taken in this paper. Some algorithm may choose the neighbor pixels around the missing data to make the interpolation polynomial whereas we use all of the pixels in horizontal direction thus more global information can be used. However Recursive form makes the reconstruction process more efficient, procession will not be slow. Suppose I is a m×n image, Let $S(x, y)$ denote the pixel within scratch, P (i, y), i≠x, i = 1...m are pixels in the same row. Inverse difference table can be constructed like below:

$$
F_{c-4}(x, y), F_{c-3}(x, y), F_{c-3}(x, y), F_{c-4}(x, y)
$$

$$
F_{c-4}(x, y) = F_{c-4}(x, y) + F_{c-4}(x, y) + \cdots + F_{c-4}(x, y)
$$

IV. CONCLUSION AND FUTURE WORK

The paper proposed vertical scratches detection algorithm based on edge detection. Edge detection is nothing but an image processing technique for finding the boundaries of objects inside images. It workings by detecting discontinuities in brightness. The proposed algorithm firstly uses the operator which has the largest response to the vertical edge in Sobel operator to detect edges, and second uses canny operator to detect additional edges. Third, we detect vertical lines in the image through probabilistic Hough transform. Finally, we obtain the true locations of the vertical lines scratches through morphology and width constraints. After the scratch detection, we find the location of vertical line scratch. These vertical line scratches remove by using new nonlinear continued fraction interpolation method. Our future work will be focus on implementation of proposed algorithm more accurate and efficient for scratch detection and removal.

REFERENCE


