Line Scratch Detection and Removal in Films

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***Abstract*— Digital media has become one of the basic need. Among which one is the video. But there are some difficulties in watching the video. Such as red colour visualization, black and white pixels randomly appearing on the screen, which has been removed by using the advanced technologies in the image processing. Also there are some problems as scratches appearing in films. Scratch detection and removal are important subjects for video restoration and image restoration. Automatic and robust algorithms are used for line scratch detection in which frame-by-frame process is done, along with that temporal algorithm is used for filtering the false detection.**

In this dissertation, the technique for detecting scratch and removing the scratch is done. In the initial technique some of the true as well as false scratches were detected. So for avoiding the false detection the advanced algorithm is adapted. The result of this will be beneficial to detect and remove the original scratches.

Index Terms— Film restoration, line scratches, line detection, false detection, Scratch Restoration.

I. INTRODUCTION

The restoration of old films is a subject of primary interest due to the great quantities of old film material present in film archives. Unfortunately, manual digital restoration is extremely time-consuming and labour intensive. The automatic or semi-automatic tools designed for the detection and restoration of defects are highly desirable. Some of the most common defects in films include dust/dirt, blotches, flicker and line scratches. Here, it considers the last defect, the line scratch, usually caused by an abrasion to the physical film. A good explanation of the physical origins of line scratches may be found at. These line scratches appear 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 several frames. Consequently, line scratch detection algorithms must be specially adapted to this defect.

However, these characteristics are very variable, making line scratch detection and restoration a particularly difficult challenge. For instance, in some cases, the scratch is semitransparent, so that some of the original image information is still available, whereas in others all the information is removed. Also, scratches are not necessarily completely straight and vertical, and their shape may in fact vary from frame to frame. Finally, although scratches can often be static, they may also move with any type of motion. It propose a line scratch detection method which is composed of two algorithms: a "spatial" algorithm which provides a pixel-precision detection of line scratches in single frames, and a "temporal" step which rejects false alarms based on information available in the whole image sequence.

The contributions are as follows. Firstly, it proposes a pixel-precision line scratch detection algorithm which is robust to the presence of noise and texture. The algorithm's robustness is due to the use of the a contrario methodology, previously used for gradient alignment detection in images. In particular, it propose a modification to the methodology which makes the detection robust to texture and clutter with characteristics that vary throughout the image. This drastically reduces the number of false alarms. The spatial algorithm presents good recall (most of the scratches are detected), with very few true scratches being rejected.

Secondly, it proposes a temporal filtering step to remove false detections left over from the spatial detection. In contrast to most previous approaches, it rejects false detections, rather than validating true scratches. This is done by using a motion coherence criterion: it consider that detections which move in the same manner as the underlying scene are not true scratches. In particular, it avoids the difficult task of tracking true scratches, whose temporal behaviour is difficult to determine. In order to decide on the rejection of detection, it also estimates robust affine scene motion. Line scratches removal algorithm is a two-stage interpolation technique. The low frequencies of the deteriorated areas are first reconstructed using a simple polynomial interpolation. Then, we deal with the higher frequencies using an appropriate model for such interpolation: Fourier series. This interpolation turned out to be a powerful method leading to a nearby invisible restoration.

II. LITERATURE SURVEY

There are several algorithms and techniques used to detect and remove a line scratch in films. Several research works are being performed by many institutions throughout the world to form the best unscratched film. This section gives a brief review on various algorithms and techniques for line scratch detection and removal in films.

A. Literature Survey

Precise spatial lines scratch detection algorithm and a temporal filtering step which eliminates false alarms. The spatial algorithm uses an a contrario validation step to determine if the detected segments are visually significant or not. The algorithm provides a precise description of the

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detected scratches, which is not given by any other fully automatic algorithm. Furthermore, it has similar performance to the state-of-the-art in simple cases, and outperforms the latter considerably in more difficult situations. The temporal filtering step eliminates false alarms which are caused by thin vertical structures belonging to the scene, by identifying scratch detections which are coherent with the scene's motion or which stop at a scene cut. Evaluations were carried out without any sequence-dependant tuning, which illustrates the robustness of the algorithm.

Line scratches are common degradations in motion picture films. An efficient method for line scratches detection strengthened by a Kalman filter. A new interpolation technique, dealing with both low and high frequencies around the line artifacts, is investigated to achieve a nearby in visible reconstruction of damaged areas. Our line scratches detection and removal techniques have been validated on several film sequences.

III. System Analysis

A. *Spatial Line Scratch Detection Algorithm*

The algorithm consists of a pixel-by-pixel scratch detection step, followed by the grouping and validation of these detections into visually significant scratch segments. Our grouping algorithm uses the a contrario methodology, a generic and automatic approach to setting detection parameters. Furthermore, we propose a modification of the classical methodology, relying on a local estimation of background models, which allows for grouping under spatially varying conditions of noise and clutter. This variant could potentially be used for other tasks.

1.1. Pixel-Wise Detection Criteria

This criterion first identifies the potential scratch points by relying on a pixel-wise detection criterion. Many other such criteria have been presented, and are based on operations such as morphological filters or extrema detection in a 1D signal. And our criterion is a close variant of the classical test introduced by Kokaram, consisting of a threshold on the difference between the grey-scale image, and a horizontally median filtered version of this image. This test basically detects outliers with respect to a horizontal neighborhood. In addition, in the image is vertically sub sampled before the thresholding, to highlight the scratches. Contrary to this original criterion, we do not take the central pixel into account when determining the median value. We also use a 3 × 3Gaussian filter with a standard deviation of one pixel to reduce the noise in the image, instead of vertical sub-sampling.

But it has a drawback of this criterion is its tendency to detect steep intensity fronts, rather than just "peaks". We avoid this by stipulating that the average grey-level values should be similar on either side of the scratch.

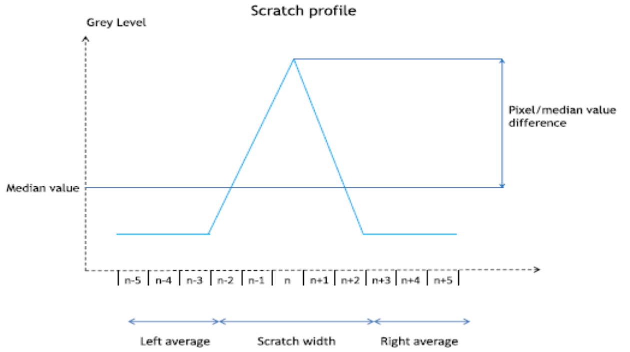
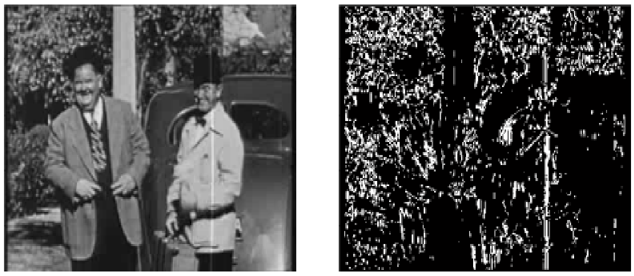


Fig 1: Line scratch profile and pixel-wise detection criteria.



(a) (b)

Fig 2: Binary detection image. White pixels are detected and black pixels are not. (a) Original frame. (b) Binary detection image.

The final pixel-wise detection criteria may be written in the following manner. Consider $I_g(x,y)$ be the Gaussian filtered grey level image. Also $I_m(x,y)$ denote the median value over a local horizontal neighborhood of pixel (x, y), and $I_l(x,y)$ and $I_r(x,y)$ be the left and right horizontal averages, as defined below. The two Boolean criteria are:

$$C_1(x,y) : |I_g(x,y) - I_m(x,y)| \geq S_{med},$$
$$C_2(x,y) : |I_l(x,y) - I_r(x,y)| \leq S_{avg}. \qquad (1)$$

Where, S_{med} and S_{avg} are grey-level thresholds. We can therefore define a binary image indicating detections as

$$I_B(x,y) = \begin{cases} 1 \text{ if } C_1(x,y) \text{ and } C_2(x,y) \\ 0 \text{ otherwise} \end{cases} \qquad (2)$$

Fig. 1 shows an example of our two detection criteria. For the proposed criteria, we can set the width of the median filter to 5 pixels, and the value of S_{med} to 3 grey levels. These values are the same as in and also appeared to us to be good choices. The left and right averages are each taken above 3 pixels on either side of the 5 central pixels, and S_{avg} has been experimentally set to 20 grey levels. These parameters were used for all the examples in the experimental section. As may be seen in Fig. 2, such a pixel-wise detection is bound to produce many false alarms, and also misses some scratch pixels. But, in order to determine the significant scratch segments present in the pixel-wise scratch detections a further grouping step is needed.

1.2. Scratch Point Grouping and Validation

An extremely robust approach is needed to group the pixels into segments. Because of false detections due to noise and texture (see Fig. 2). One of the most well-known methods of detecting prominent lines in binary images is the Hough transform, for the grouping of scratch detections. But unfortunately, this approach contains thresholds which need to be tuned from sequence to sequence, and does not offer a precise spatial localization of line segments. In order to group the pixel-wise detections, we turn to a more sophisticated set of methods known as a contrario methods, used for alignment detection. In a word, the a contrario methodology is a generic way to detect visual objects in digital images. Detection thresholds are set in order to control the number of false detections in a white noise image, or more generally under a background model. This model usually relies on an independence assumption on the basic elements to be grouped for the detection. A group is validated as soon as it is very unlikely that this group has been generated by the background model. That is, groups are detected when they are very unlikely under the hypothesis that basic elements are independent.

B. TEMPORAL FILTERING ALGORITHM

Although the spatial line scratch detection algorithm detects line scratches with good spatial precision and is robust to noise and texture, it does not deal with the problem of false alarms due to thin vertical structures that are part of the captured scene. On a frame-by-frame basis, these closely resemble line scratches. In some situations, it is practically impossible to differentiate the two without prior knowledge concerning the scene structure. Unfortunately this sort of knowledge is difficult to obtain and use. One other way to distinguish between true and false scratches is to use temporal information contained in the image sequence. Since scratches are caused by physical damage to the actual film, their motion is completely independent of that of the scene. Therefore, any detections displaying motion which is coherent with the scene should correspond to false detections.

Consequently, we reject any scratch detection having a trajectory which conforms to the dominant scene motion. We shall refer to this criterion as the motion coherence criterion. This criterion does not deal with scratches which move with the scene, or are completely still in a static scene. However, such situations are impossible to resolve without prior knowledge on the nature of scratches.

C. LINE SCRATCH REMOVAL

This stage is the post processing the detection field. To reconstruct we use an interpolation method for corrupted pixels of the detected line scratches. Image interpolation procedures falls into three main categories: contour-based, intensity-based and shape-based interpolations. In our case, we involve an intensity-based interpolation. This technique takes the original pixel intensity value and generates new interpolated pixel intensity. The calculation of the interpolated value takes a limited number of data points within a small neighborhood. Two kinds of neighborhood may then be used

- Extracted from the current frame of a spatial neighborhood,

- Extracted from the current image and the preceding and/or the following frames of the sequence of a spatio-temporal neighborhood.

For old film restoration as computing power is an important factor, we use a spatial neighborhood around the line scratches. Let us notice that line scratches width is limited to a few pixels, so, using only the pixels surrounding these deteriorations in the current frame seems to be sufficient for efficient interpolation.

3.1. IMAGE INTERPOLATION METHOD

The first step is to propose a mathematical model for the luminance variation to catch a local interaction of some neighbor pixels in the design of an image interpolation algorithm. One can then develop a method which fits this form to the observed image. The main interpolation models used in signal and image processing are:

- Polynomial models,
- Stochastic models and
- Fourier series

First the polynomial interpolation usually relies on splines or Bsplines representations which are the basis for curve fitting. The only requirement of such methods is the order of the polynomial which best fits the input signal. This is a good solution for the reconstruction of homogeneous regions. However, it fails to reconstruct regions of high activity such as textured areas because it approximates only the low frequencies of the input signal.

Stochastic models such as AutoRegressive (AR) models or Markov Random Field (MRF) models are also widely used for spatial interpolation process. They allow a better interpolation than polynomial models. Indeed, the high frequencies which are lost in polynomial interpolation may be recovered using such stochastic interpolation procedure. However, they are difficult to implement.

Fourier series allow a simple representation of input signals either with low or/and high frequency components. While polynomial and stochastic models require the knowledge of the model order, the use of Fourier series only depends on the number of samples of the discrete signal.

3.2. A TWO-STAGES RESTORATION METHOD

We propose a two-stage restoration approach for to completely remove a line artifact, which first reconstructs low frequency components and then deals with higher frequencies. Let us emphasize that errors in the reconstruction of line scratches are more visible than in the case of blotches. Indeed, line scratches usually persist across several frames. Therefore, reconstructed line areas have to be as close as possible to the original patch.

3.2.1. LOW PASS IMAGE RECONSTRUCTION

For old film restoration classical methods such as low-pass filters or median filters are not appropriate tools because they worse high frequency components of the images. Low-pass image reconstruction method is a polynomial interpolation based on a cubic polynomial which is the simplest model to approximate low frequency components of an image.

3.2.2. HIGH PASS IMAGE RECONSTRUCTION

High pass image reconstruction technique exists but most of them do not or just partially deal with such type for image restoration techniques. Very few research works has been developed to this issue. And mostly they are based on video format. On Fourier series we propose a high-pass image reconstruction technique. We extract the high frequencies from the area which has been used for the reconstruction of low frequencies of the line artifact region. Because of oscillatory nature of Fourier series are mostly likely to fit high frequencies of image. Then the reconstructed high frequencies components of line artifact area are added to the previously computed low frequency signal to complete our two-stage reconstruction process.

IV. CONCLUSION

Precise spatial lines scratch detection algorithm and a temporal filtering step which eliminates false alarms. The spatial algorithm uses an a contrario validation step to determine if the detected segments are visually significant or not. Our algorithm provides a precise description of the detected scratches, which is not given by any other fully automatic algorithm. And our line scratches removal algorithm is a two-stage interpolation technique. The low frequencies of the deteriorated areas are first reconstructed using a simple polynomial interpolation. Then, we deal with the higher frequencies using an appropriate model for interpolation.

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