International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-4 Issue-5, June 2015

Automatic Line Scratch Detection and Restoration in Films

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Abstract: ***Line scratches are the most common defects in old films. They are caused by the abrasions of the film material as it passes through the projection mechanism. Once an image is digitized, its defects become part of that image .So scratch detection and removal is important subject for video restoration. This work presents a technique for detecting and removing these line artifacts .Using A Contrario line scratch detection, we detect and locate line scratches accurately, after that a new digital image inpainting algorithm based on directional median filter is used to remove these scratches. In Contrario line scratch detection method along with Spatial detection algorithm, a Temporal filtering algorithm is used for filtering false detections. As a result we can detect and remove original scratches. This work discuss about frame conversion from a digital video of specific length. Pre-process the frame in order to enhance image quality and then perform scratch detection and removal. Final video is once again formed from the processed frames. The overall system is developed in matlab and results are analyzed .Results shows that the proposed method can detect more line artifacts with less false detection and remove the line scratches effectively.***

Index Terms: Scratch detection, A Contrario method, inpainting, spatialdetection, Temporal filtering algorithm, Directional median filter, video restoration

I. INTRODUCTION

Last few years, many algorithms were developed for digital film restoration to enhance image quality. The main purpose of this algorithm is to achieve a good quality restoration and employing a low computing time with least amount of operator's interaction. Line scratches are the most common defects in old films, they are caused by abrasion of film material during its transport or in the film developing process. In this paper we concentrate on automatic line scratch detection and restoration. Scratches appeared in videos in the form of dark or bright almost straight vertical lines with width of 3 to 10 pixels. Unlike dirt scratches persist in the same spatial location for more than one frames. Ane.g. of an image affected by scratch is shown in fig (a)

Fig. (a)

Manuscript published on 30 June 2015.
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To remove scratches from video manually is highly a difficult and time consuming task .Hence some automatic or semi-automatictools are highly required to detect such scratches sincelarge quantities of scratched old film material present in film archives. Video is a collection of successive frames. One film video contains large number of frames soafter scratch detection, removal of these scratches is again an important and challenging task. In our project we present a robust technique for scratch detection and removal in frames of video and then combine the scratch removed frames to form scratch removed video and thereby we enhance the image quality. For scratch detection we use two algorithms 1.Spatial 2Temporal .Spatial algorithm provides a pixel-precision detection of line scratches in single frames and the Temporal step reject false alarms based on information available in the image sequence, that is the position of scratch remainsin the same position for more than three of the consecutive frames. Afterscratch detection, detected scratches are removed using an image inpainting method which is based on directional median filter

II. LITERATURE SURVEY

There are several algorithms and techniques used to detect and remove line scratches in films. Several research works are being performed by many institutions throughout the world to obtain the best unscratched film. This section gives a brief review on various algorithms and techniques for line scratch detection and removal in films. Base paper [1] proposed a solutionthat hasthe advantageto avoid false detection from scratched video. This paper proposed a Frame-By-Frame scratch detection algorithm and temporal filtering algorithm. Removal is based on paper [2]. The first work on this subject was carried out by Kokaram [3], and introduced a scratch model which is widely used in other papers ([4] and [5]).These approaches are considered to be among the most efficient scratch detection methods. In other methods such as [6] and [7], scratches are detected in wavelet domain. Hough transform is used in both [3] and [8] to detect prominent lines. Paper [12] focus on line scratch detection, it consist of two steps: a neural network based texture classifier and a morphology based shape filter with multiple structuring elements.Temporal approaches may be found in [9], [10], the main goal of these temporal algorithm is to validate scratches using certain temporal hypothesis. After detection of scratches, median filtering technique discussed in [2] is employed to remove these scratches. There are many unresolved problems with the above mentioned approaches. Firstly, the scratch is represented as a straight, vertical line.

This may not be the case in most of the examples which are commonly shown in many of the papers. In some examples, the slant of the scratch may be quite significant, which renders the vertical representation almost useless for restoration purposes. Another major problem with the prior work on the subject is that, there was no temporal algorithm to avoid false detections. But in our method we propose a robust Temporal Filtering algorithm

III. PROPOSED METHOD

The entire block diagram of the proposed method is shown in Fig (b) and the steps are described below

1. Video to frame conversion: Using matlab we convert video to frames. **2.** Image pre-processing: This step isusedto avoid noise in videoframes. **3.** Spatial scratchdetection: Thisstep detect visually significant scratch segment by considering only the current frame. **4.** Temporal scratch detection: It eliminates false detections by using temporalinformation contained in the imagesequence. **5.** Frame scratch removal: In this step an inpainting algorithm based on directional median filter is used to remove scratches in the frames. **6.** Frames to videoconversion: Finally using matlabwe combine the scratch removed frames to form the unscratched videoSpatial scratch detection and Temporal filtering algorithms are the main algorithms in the scratch detection process

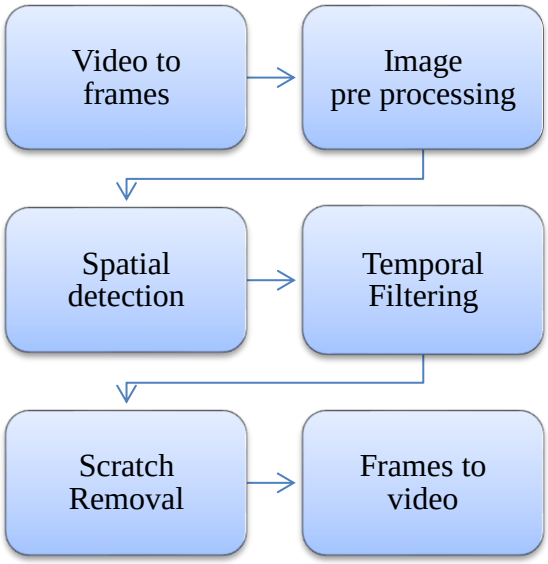

Fig. (b) Flow chart of Scratch Detection and Removal

The entire method is divided in to two stages, one is Scratch Detection and other Scratch Removal. The Scratch Detection stage consist of two algorithms Spatial and Temporal

A. Spatial Detection

This algorithm consist of two steps

1. Pixel wise scratch point detection

Inthisstep, we identified the scratch point by pixel-wise detectioncriterion, this criteria can be explained as:

$I_g(x,y)$: Gaussian filtered grey level image.

$I_m(x,y)$: Median value over a local horizontal Neighboring pixel (x, y),

$I_l(x,y)$: The left horizontal averages

$I_r(x,y)$: Right horizontal averages

S_{med}, S_{avg} Grey-level thresholds and experimentally set these values as 3, 20 grey levels respectively

Then,

$$C_1(x,y): |I_g(x,y) - I_m(x,y)| \geq S_{med} \quad (1)$$

$$C_2(x,y): |I_l(x,y) - I_r(x,y)| \leq S_{avg} \quad (2)$$

If $C_1(x,y) and\ C_2(x,y)$

THEN

$$I_B(x,y) = 1$$

ELSE

$$I_B(x,y) = 0$$

Where $I_B(x,y)$ is the binarydetected image and this detectionmay produce many false alarms, and also misses some scratch pixels. The entire steps in spatial detection algorithm is shown in fig (d) Pixel-Wise Detection Criteria is illustrate below White pixels are detected pixels and black Pixels are not. Fig (a) Original frame. Fig (c) Binary detection image

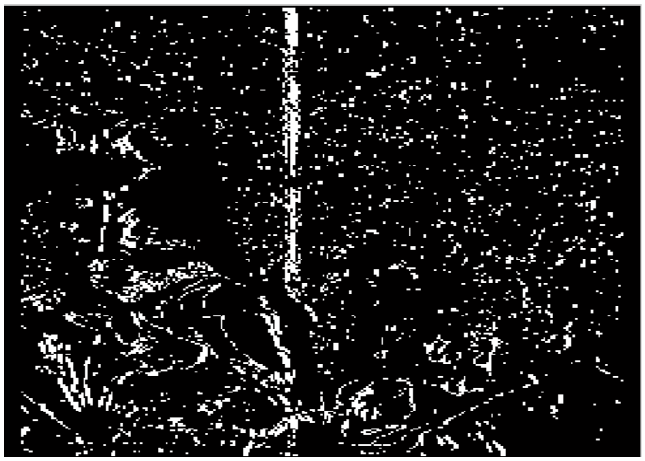

Fig. (c) Binary detected image

2. Scratch Point Grouping and Validation

A robust method is need to group the detected scratch point in to scratch lines because of false detections due to noise and texture as shown in Fig(c).So we use a more sophisticated method known as a contrario method, used for alignment detection by Desolneux et al [11].The contrario technique is a way to detect visual objects in digital images. The steps are described below and summary diagram is shown in Fig (d) & output in Fig (e)

2.1. Contrario Line Segment Detection:

Here, the basic elements to be grouped are pixels, and segments are detected as group of pixels whose gradients are perpendicular to a given direction. Given a line segment made of l pixels, a variable $x_i$is associatedto each pixel. The variable x_i is equal to 1 if the pixel isaligned with the segment and 0 otherwise. Aligned pixels are those whose gradient orientation is orthogonal to the segment orientation, up to some angular precision pπ radians, with∈[0, 1]. Let s = x1+ · · · + $x_l$be the number of aligned pixels. This is the quantity upon which the detection of segments is based. Larger values of s are associated to more meaningful line segments. The detection of segments require thresholds that depend on l and p and are therefore non-trivially set.

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The aim of thecontrario approach is precisely to set these thresholds. Segments of length l having k_0 aligned pixels are meaningful when B (p;k_0, l)is small enough, a threshold must be assigned to this probability so we take the total numberof tested segments into account. For this we consider the number of false alarms (NFA)

$$NFA(l, k_0) = N_{test} B(p; k_{0,} l) \quad (3)$$

Where N_{test} is the total number of segments to be tested $N_{test} = M^2 N^2$,with M and N the linear dimensions of the image. A segment is detected if $NFA(l, k_0) \leq \in$ for some parameter $\in$

2.2.Maximality: After contrario detection,many redundant segments are detected this is because a very meaningful segment often contains, and is contained by other segments which are $\in$-meaningful. In order to maintain only the best detection for such cases, we use the criterion ofMaximality, as introduced in [13]. A segment is maximal meaningfulif it neither contains, nor is contained, by a segment with smaller NFA

2.3. Exclusion Principle

Since scratches have a width of several pixels, different segment may correspond to the same scratchsofor restoration purposes we would like as precise a representation of the scratches as possible. We use an Exclusion principles defined in [11], which states that a pixel may belong to one scratch only. If a pixel S is contained by several segments, then the most meaningful segment retains Sand all other segments which contain Shave this pixel removed. The NFAs of the modified segments are then recalculated and those have more $\in$ values are discarded. This principle is not only applied to pixels which belong to several segments, but also to those which are at a distance of $\tau x$from more than one segment. In our experiments, we set τx to three pixels

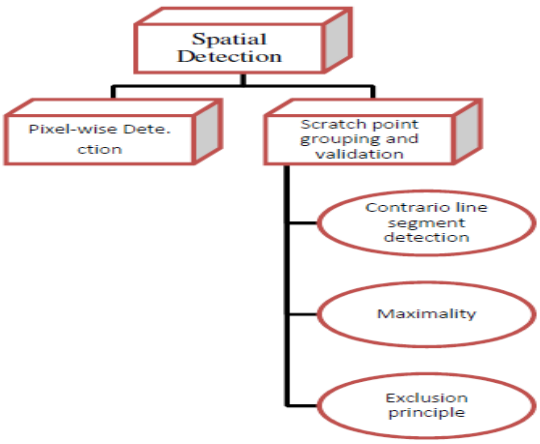


Fig. (d) Summary diagram of spatial algorithm

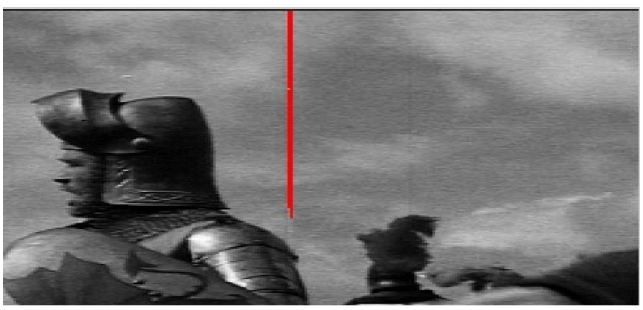
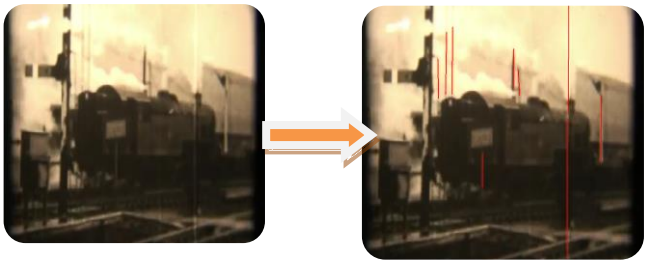


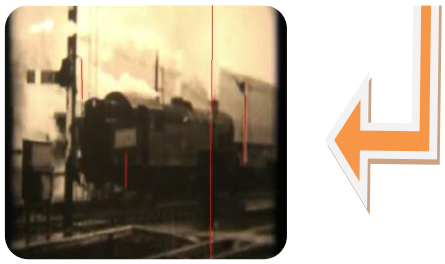
Fig. (e)

B. Temporal algorithm

Even though the spatial line scratch detection algorithm detects line scratches with good spatial precision and 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 vertical structures closely resemble line scratches, but they are not. So we must developa new algorithm to detect these false detection. 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. The red lines in the Fig.below shows the scratch lines. Spatial output contains 8 red lines, of which two are real &six are false detections. But we could remove some of these false detections by Temporal Filtering algorithm and thereby we improved the performance parameters such as Precision, Recalletc.



Input frame **Spatial output**



Temporal output

C. Scratch Removal

We propose a new inpaintingalgorithmbased on median filters. The proposed algorithm explained is fast, very simple to implement and provides very adequate results in both high contrast edges and smooth regions. The algorithm is iterative and, according to our experimental studies, it converges at most in 2 or 3 iteration for simple damaged regions. For complex damaged regions, a larger number of iterations will be needed.

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The proposed algorithm is as follows. After determining damaged regions, the algorithm considers one pixel thick boundary of the missed region. For each missed pixel on the boundary, known pixels in different directions are selected then, the median value in each direction is determined, and finally, the damaged pixel value is considered to be the median of these medians. Once, all of damaged boundary pixels are reconstructed, the algorithm has finished its first iteration. In next iteration, the new boundary is first calculated. Then in a similar manner, the boundary pixels are reconstructed.

Different steps of the algorithm are as follows.

a) Find one pixel thick damaged boundary.

b) Determine known pixels in several directions around the current pixel.

c) Compute median of these determined pixels indifferent directions.

d) Compute median of obtained values in previous step and pass it in current pixel

e) Shrink damaged region one pixel .The scratch removed frame is shown in fig (g)

Fig. (g) Scratch removed Frame

IV. CONCLUSIONS

In this paper, a precise spatial line scratch detection algorithm and temporal filtering algorithm are used. The spatial algorithm uses acontrario validation step to check whether the detected segments are visually significant or not. 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 scene motion. Our algorithm provides a precise description of the detected scratches, which is not given by any other fully automatic algorithm. And our line scratch removal algorithm is a new digital image inpainting algorithm based on directional median filter and this algorithm is fast and provides adequate results in sharp edge regions.

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