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Automatic Line Scratch Detection and Removal in Digitized Film Sequence

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ABSTRACT

Video restoration or old film restoration is challenging but sometimes necessary process. Line scratches in old videos appear as thin bright or dark lines which are roughly vertical and straight. We propose, Frame – By – Frame line scratch detection algorithm to detect scratches from old films. For false detection temporal algorithm is used. Some assumptions and hypothesis from old scratch removal strategies are eliminated from Frame-By-Frame line scratch detection algorithm so that variety of line scratches can be detected. Contrario methodology and local statistical estimation is used in combinatorial way for robustness. Using these technologies over detection and confusion creating areas are greatly reduced. Vertical structure in video can cause false detection but temporal filtering algorithm eliminates false detection by considering and analyzing unity of underlying scenes. We contribute for removal of scratches using pixel filling technique. This concept of detecting and eliminating line scratch from video contribute fine methods for video restoration.

Introduction

In early age, video films are recorded in digital tapes. Manual handling, dust, dirt or abrasion by contacts of a tape with mechanical parts like film projector affects the storage media hardware and hence causes scratches in video. These scratches can be appeared in videos in the form of dark or bright thin straight vertical line. It always in the form of Line scratches are very common to the old videos. Sometimes these lines may persist in the same or similar position in successive frames. This is known as temporal persistence.

The restoration of old films is a subject of primary interest of work due to the great quantities of old film material present in film archives. Video is a collection of successive frames. One film video contains huge number of frames. To remove scratches from videos manually is highly cumbersome and time consuming task. Hence some automatic or semi-automatic tools are highly required to detect such scratches. After scratches detection removal of those scratches is again an important and challenging task.

Line scratch detection and restoration is challenging task. In some cases scratch may be semi transparent i.e. original image is still available with the scratch or sometimes it may erase the complete information. Scratch may have in different shape like curve.

In our project we present a technique for scratches detection and removal of those scratches from video to increase quality of a video. For scratch detection we have used pixel scratch detection technique. We collect the detected scratch pixel ad indentifies the shape, using which we remove false detections. As scratches are independent form moving objects in adjacent frames we use a temporal technique with motion coherence to remove false alarm by comparing motion of object. Detected scratches are removed using pixel filling technique.

Literature Survey

Base paper [1] proposed a solution for scratch detection and to avoid false detection from video. This paper proposed Frame-By-Frame scratch detection algorithm and temporal filtering algorithm.

To get basic idea for video error and video quality faults [2] is helpful for us. This is online reference. It basically explains what scratch on film exactly means. It explains what is tearing , scratching , cinching , machine scratching , base scratching , emulsion scratching , water damage and other blemishes shortly but perfectly. It helps us to decide the area of interest as far as scratches on film is concern. It gives us basic idea of scratches and damages on film.

To work on meaningful geometrical structures and to study image alignment [3] proposed method. These methods are detecting geometric structures in an image, without any a priori information. It discussed the contrario technique that helps to maintain the robustness in line scratch detection algorithm.

Automatic scratch detection and removal approach for archive sequences is discussed in [4]. Proposed method is focused to get scratch positions by using their temporal coherency. Spatial and temporal information are also considered and employed when restoration of particular video is in progress. Edge priority based scratch removal algorithm is used to remove scratch effects from targeted films.

Another technique is discussed in [5] for automatic scratch detection. It provides fast and cost-effective solution for it. Due to vertical images in video, false detection increases. It avoids such false detection. Image structure, precise motion information and texture are considered to separate out scratches.

From advancement in scratch detection, paper [6] proposed idea for line scratch detection. For this it considers spatial detailed information by considering frame-by- frame analysis. It also considers the motion information for betterment of result.

To get an idea of special model for line scratch detection [7] first introduce the idea.

In similar manner [8] also proposed interesting approach for line scratch detection. It considers light diffraction for it. Also it proves that light diffraction gives rise to scratches.

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Paper [9] is also having same focus of line scratch detection. It consist of two modules : a neural network-based texture classifier and a morphology-based shape filter with multiple structuring elements.

After detection of scratches, median filtering technique is discussed in [10] for removal of scratches. This removal of scratches may sometime deform the unexpected area to avoid this median filter is used, interpolation of signal with variable window technique is used. Hough transform is used to detect straight line element around the scratch. After definite line element median filtering is performed. With combination of detection and filtering film scratches are effectively removed.

While detecting the scratch we have to first validate the detections. This is achieved with the help of temporal algorithm discussed in [11]. This paper proposed the proper detection process is proposed for line scratches removal. While detecting the scratch two steps are followed. Firstly candidate line scratches are determined. Then using the Kalman filter these candidate line scratches are tracked over frame sequence to avoid false scratches.

For degraded motion picture line scratch detection algorithm is used and some techniques are proposed in [12]. Here also explicit expected line and unexpected lines are tracked. Here also the Kalman filter is applied. Bayesian restoration technique is used for detection of deteriorations.

As per literature survey, there are basic techniques that help us to find line scratches in videos and some techniques help to remove those scratches. Based on the techniques discussed in the papers it is challenging to find very thin scratch and track it frame by frame. Also particularly block matching is not well adapted to such structures. Discussed survey is just calculate the global motion which is very basic and non robust. Hence there must be system that traces line scratches on video in automatic and robust manner.

Problem Statement

We have n old films black and white videos V1, V2,…, Vn we have to process those videos by converting each video in k number of frames F1, F2,…,Fk. The value of k varies for each Vi in V. Identify scratches in each frame. Remove false detection scratches and consider image sequence to identify scratches. Remove scratches form each frame Fi and reconstruct refined video Vr1, Vr2,….Vrn.

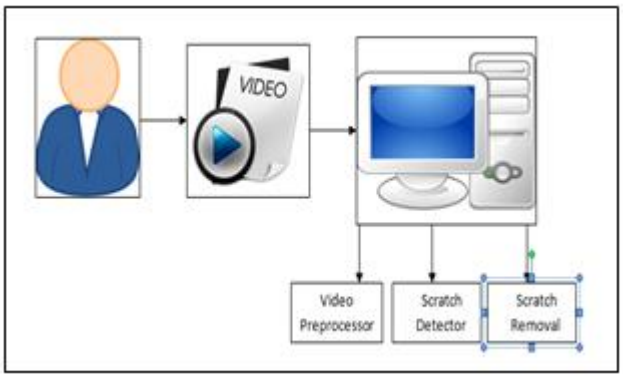

Figure 1. System Architecture

In our proposed system, we have accepted one raw black and white video with scratches from user. We filter that is raw video ad generate refined video with removal of maximum scratches.

For video processing we have divided video in k number of frames and each frame is processed individually to identify scratches. For scratch identification we have used pixel-by-pixel scratch detection technique. By grouping those pixels in a shape, we validate these detected shapes and identify visually significant scratch segments. Grouping of a pixel is done using Contrario technology. This technique helps to detect geometric structures in an image: It identifies alignments of shape like contrasted curves, smooth curves. It also identifies objects of same characteristic like color, size, shape. To remove false detected scratches we compare scratches with adjacent frames using temporal technique. After scratch detection we removed those scratches using pixel filling technique and regenerate the video.

Pixel Detection

This technique detects outliers i.e. scratch pixel with respect to horizontal neighbouring pixels. For this we have use 5*5 Gaussian filter.

This criteria can be explained as:

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

Im(x, y): median value over a local horizontal neighboring pixel (x, y),

Il (x, y) the left horizontal averages

Ir (x, y) right horizontal averages

smed , savg: grey-level thresholds

Then,

$c1(x, y) : |Ig(x, y) - Im(x, y)| \geq smed$,

$c2(x, y) : |Il(x, y) - Ir(x, y)| \leq savg.$

if c1(x, y) and c2(x, y)

THEN

IB(x, y) = 1

ELSE

IB(x, y) = 0

Pixel-Wise Detection Criteria can be illustrated with an example. White pixels are detected pixels and black pixels are ignored. (a) Original frame. (b) Binary detection image.

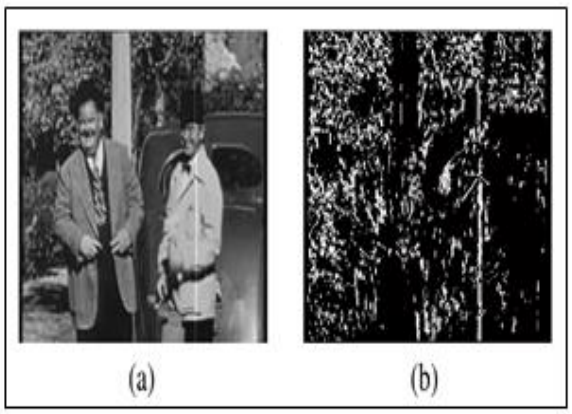

Figure 2. Original frame and Binary frame

Pixel-wise detection generates many false alarms i.e. false detections, and also skips some scratch pixels. A next grouping step is required to determine the significant scratch segments from the pixels in the pixel-wise scratch detections.

Scratch Point Grouping and Validation

The contrario technique is a way to detect visual objects in digital images. For white noise images, detection thresholds can be set to control false detections.

In our project we group the pixels from pixel-wise detections technique. A group is validated as soon as it is very unlikely.

Contrario Line Segment Detection

In this case, the basic elements to be grouped are pixels, and segments are detected as groups of pixels whose gradients are perpendicular to a given direction. Given a line segment made of l pixels, a variable xi is associated to each pixel. The variable xi is equal to 1 if the pixel is aligned 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 p ∈ [0, 1]. Let s = x1 + · · · + xl 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. The aim of the contrario approach is precisely to set these thresholds. The detection relies on the probability distribution of s under some background model.

Temporal Filtering

In a film, motion of an object is completely independent from the background scene. Any detection from moving object in scene leads to false detection. Temporal technique identifies false detection of scratches in a frame by comparing the frame objects with adjacent frames.

For this we have used motion coherence technique. In this we determine whether scene has been moved during a trajectory’s time span. For this, we *horizontal* motion of the scene. We identifies original positions of object as a trajectory set. This helps to identify motion in successive frames.

Two Segments *Q* and *R* belonging to this set which verify the following inequality:

$| x(Q) - x(R) | \geq \tau m,$ (13)

where τm is a motion threshold. This corresponds to the *absolute distance* that the scene has moved between the frames t(Q) and t(R).

Pixel Filling

The existing system[1] works on scratch detection. We have extended our work with scratch removal technique.

For Pixel filling technique we are using median value of vertical adjacent pixels of scratch mark.

$$Up = p(x-dx-\frac{w}{2}, y-dy)$$

$$Down = p(x+dx-\frac{w}{2}, y+dy)$$

$$V = \frac{(p(x1,y)+p(x+w,y))}{2}$$

P(x,y) = median(up, down, v)

Dx and dy are the components of the estimated direction vector. If up and down values are same then , the new pixel value will be one of them. If they are very different, we choose the vertical interpolated value, which is in the middle of the other two.

The restored area is then rerotated and replaced into the original damaged area. Finally, a median filter is applied to the boundary of the scratch mask, to remove some residual artifacts. Experiments showed that the quality of the results is independent of the rotation angle.

Algorithms

System Algorithm

Input

Mp4 Black and White Video

Output

Refined video with scratch removal

Processing

1. Initialize: smed = 3, savg=20
2. Accept video V
3. Convert V into fn frames
4. For each frame 1 to n
5. Convert each image as grey scale image as Ig(x, y)
6. Apply gausinan filter for pixel noise detection
7. Im(x, y) = Ir (x, y) + Il (x, y) / 2
8. Calculate :c1(x, y) : |Ig(x, y) − Im(x, y)|
   c2(x, y) : |Il (x, y) − Ir (x, y)|
9. if c1(x, y) >= s-med and c2(x, y)<= s-avg then
10. IB(x, y) = 1
11. Else
12. IB(x, y) = 0
13. End If
14. Identify line and curves scratch using Contrario method
15. Remove false scratch using temporal echnique.
16. Remove scratches using pixel filling technique.
17. End For
18. Generate video from frames

Gaussian Filter Algorithm

Input

Video Frame Image

Output

Scratch Pixel Detection Frame Image

Processing

1. The original frame image is taken as X.
2. The noise standard deviation (SD) from frame image is calculated using Immerkaer’s fast method.
3For each pixel matrix m of size 5*5 from the original frame image
4. calculate the center pixel X(i,j).
5. In the window, subtract each element with the center pixel and the absolute value of the difference is calculated as AD
AD = | Sij – X(i,j)| .
6. If the absolute difference AD < (SF*SD) (where SF is the smoothing factor and SD is the standard deviation)
7. store the corresponding pixels in a one dimensional array as DA(x).
8. If the number of elements in the DA(x) is at least (2*W) -1 then
9.Calculate mean of DA(x) is calculated.
10. For each X(i,j)
11. If X(I,j) < DA(x)
12. Mark X(I,j) as scratch
13. End For
14. End For

Contrario Algorithm

Input

An image I, a model with K parts, and a threshold ǫ.

Output

False detection

Processing

1. Sample the image in a stride of 4 pixels, extract a set of features
2. Ac l is the histogram of local intensity gradient orientations appearance descriptor calculated over a 16 × 16 pixel region and S is the corresponding location
3. Specify a set of sub image candidates and find candidate features.
4. Calculate the distance between the model and the sub image candidate
5. Calculate the expected number of false detections

Mathematical Model

S={I,O,F}

I1 = Video File

I2 = Median Filter

I3 = Grey Levels

I4 = Motion threshold

F = {F1, F2, F3, F4, F5, F6, F7, F8}

F1 = Upload video

F2 = Create Frames

Table 1. Comparison with different videos

Video Size	No of scratches	Time required	Video
5.7	44	12	knite
7.6	118	23	sitdwn
24	30	16	Afgrunden gate
94	238	28	Keldjian

F3 = Binary frame conversion
F4 = Pixel wise Scratch Detection
F5 = Scratch point grouping
F6 = Contrario line segment detection
F7 = Motion cohenrence
F8 = False detection removal
O = {O1, O2, O3, O4}
O1 = Frames from video
O2 = Binary image from frame
O3 = Final scratch removed frames
O4 = video construction

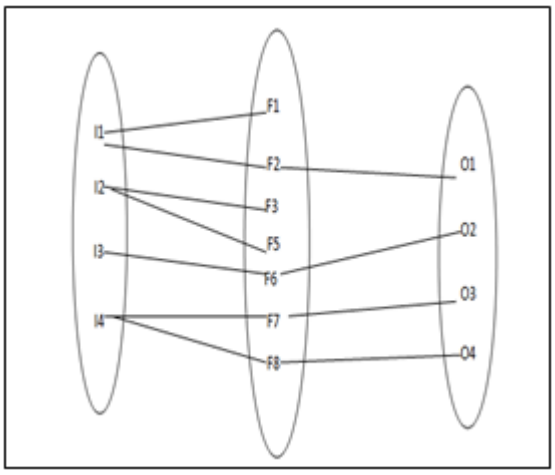

Figure 3. Mathematical Model

Implementation

We have developed our system in java. For this we have used jdk1.7 environment on windows 7 system with 2.3Gz Core-I3 processor with 2gb RAM and 320GB hard disk. We have created desktop application with swing component GUI.s

Dataset

We have collected old black and white mp4 video from video archives.

Link: https://archive.org/details/movies

Experimental Setup

We have installed application jar file in windows 7 system. We have downloaded old films black and white videos. The size of these videos is huge. For testing we have cropped the video using video cutter tool. For testing we have cropped the film video up to 1 minute video.

We have also tested our system for videos present in following dataset link.

We have tested our system performance on different machine with different hardware configuration like :core 2 duo processor with 1 gb RAM. , core-i3 with 1GB / 2GB RAM. We have also tested our setup jar file working on linux environment.

Results

In our system we have identifies scratches and removed scratches from video. Following fig shows 3 images. The first image is the original image with scratches. These scratches are identified by our system and highlighted using green color line. This is represented in the 2nd image. Using pixel filling technique system removes those scratches and creates new image. This is represented in 3d image.

Following is the time estimation for processing different video using our system.

The graphical representation of time estimation with no of scratches and video size.

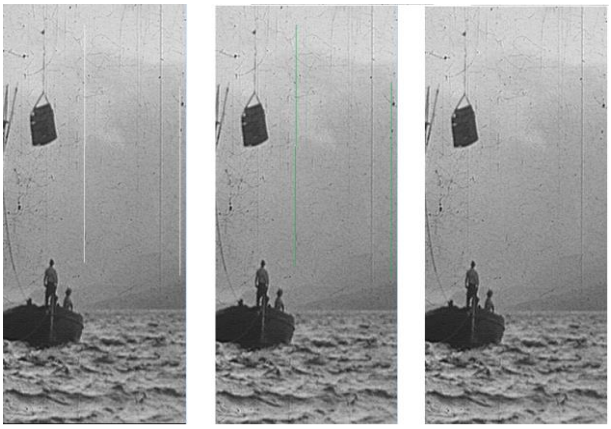

Figure 4. Result

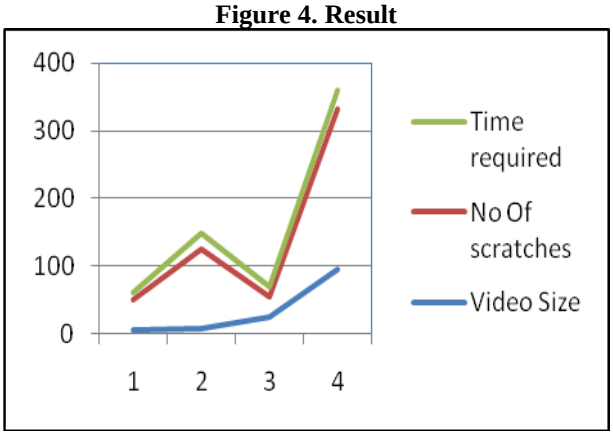

Figure 5. Graphical representation of Time with Scratches

We have detected scratches from video and calculated Precision and recall values.

Precision = N/T.

Where ,

N= the number of true detections

T= the total number of detections

Recall = (N/ OS) *100

Where,

N = scatch detected

original scratches

Table 2. Precision and Recall

Video	Total Scratches	Precision	Recall
knite	44	93.61	88
sitdwn	123	96.72	77.63
Afgrunden gate	34	100	88.23
Keldjian	245	97.64	91.18

Conclusion

In our system we have presented a precise line scratch detection and video restoration algorithms. A temporal filtering technique removes the false detections. A contrario method determines whether detected scratch segment are visually significant or not. The pixel filling technique helps to remove scratches in the frame with median value of neighboring pixels.

Our algorithm works for sequence independent frame tuning and hence proved the robustness.

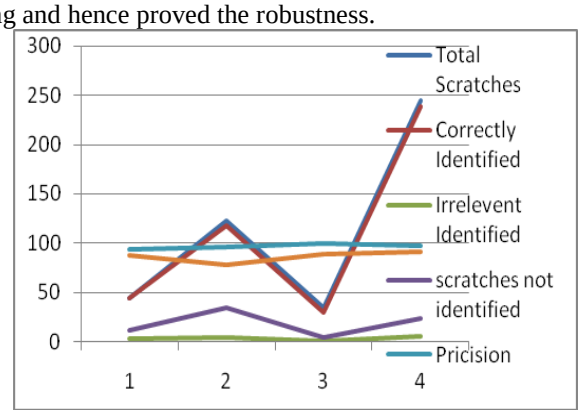

Figure 6. Graphical representation of scratches

In future we will work on color videos for scratch detection and removal.

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