COE 4TN4 Course Project 2:
Detection and Removal of Scratches in Old Films

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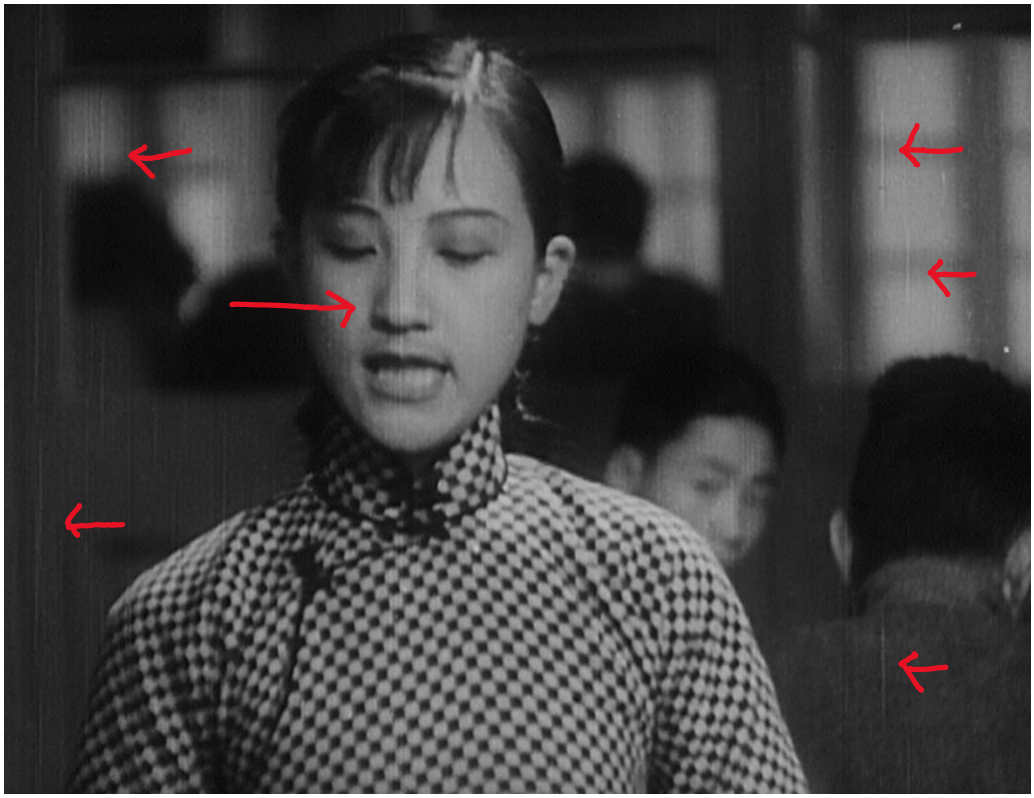
1 Problem

In old motion picture films, line scratches are common artifacts. An example is shown below. In this project, a vertical scratch detection algorithm is implemented, and a restoration algorithm is created in attempt to remove the scratches of the image.



2 Task 1: Scratch Detection

The formulation of the algorithm is implemented based on the characteristics that have been discovered while looking through the images and the pixel values. These are the results:

- Width of the scratches are about 3-5 pixels
- The intensity of the line scratches is higher than image edges (i.e. table, walls, etc.)

- The center of line scratches shows little fluctuation and remains almost constant

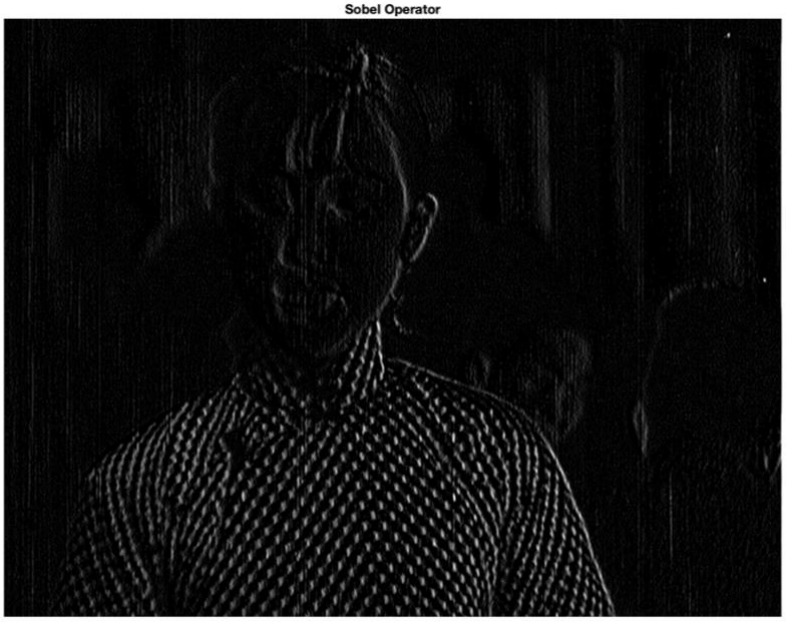
Based on these characteristics, a vertical scratch detection algorithm is formulated. Below shows the following steps:

1. Sobel Edge Detection

   A Sobel operator, specifically the vertical edge detection shown below, is used for computing the gradient approximation of image brightness function. This will detect all the vertical edges in the image.

−1	0	1
−2	0	2
−1	0	1

Sobel Operator



2. Canny Edge Detection

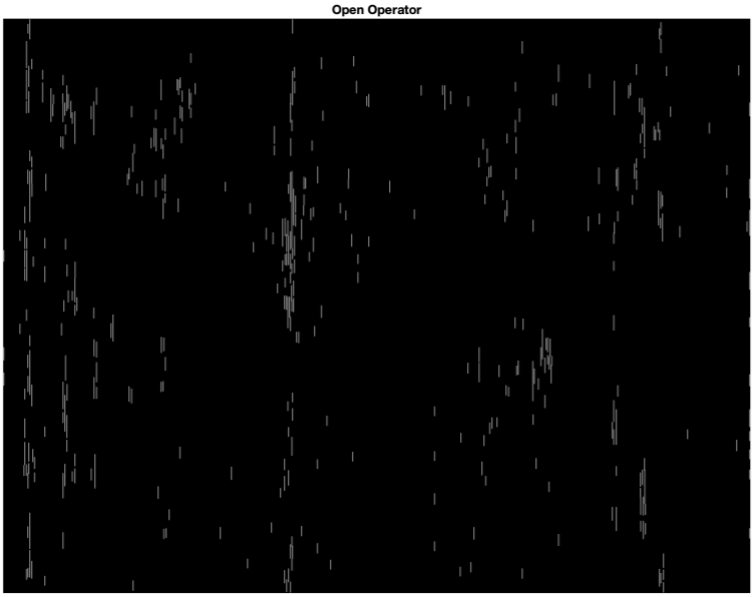
   The Canny operator is used for multi-scale edge detection. This operator uses a Gaussian function to smooth the image. Then the magnitude and the direction of the gradient is computed and then magnitude of the gradient is supressed by the non-maxima. This will result in detecting and connecting the edges. The built-in function “edge(image, ‘canny’)” is used. The resulting image is a binary image.

3. Open Operation in Morphology Processing

The result of the image from the step below is now a binary image where white (pixel value is 1) shows all the edges. It is still noticeable that there are still false edge detections/natural vertical objects among the lines. To get rid of these lines, the opening operation in Morphological processing is used. This removes fake scratches and edges and can eventually get the locations of the real ones.

$$A \circ B = (A(-)B) \oplus B$$

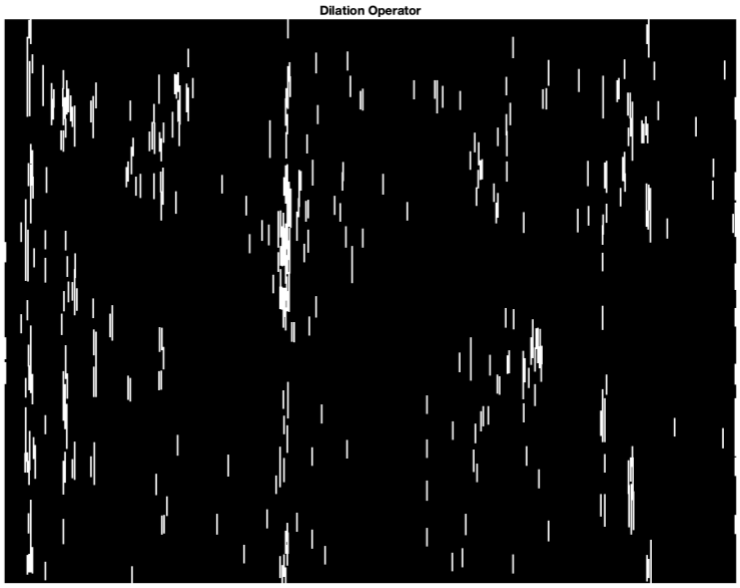
where A is the image and B is the structuring element of a line (17x1)



4. Dilation

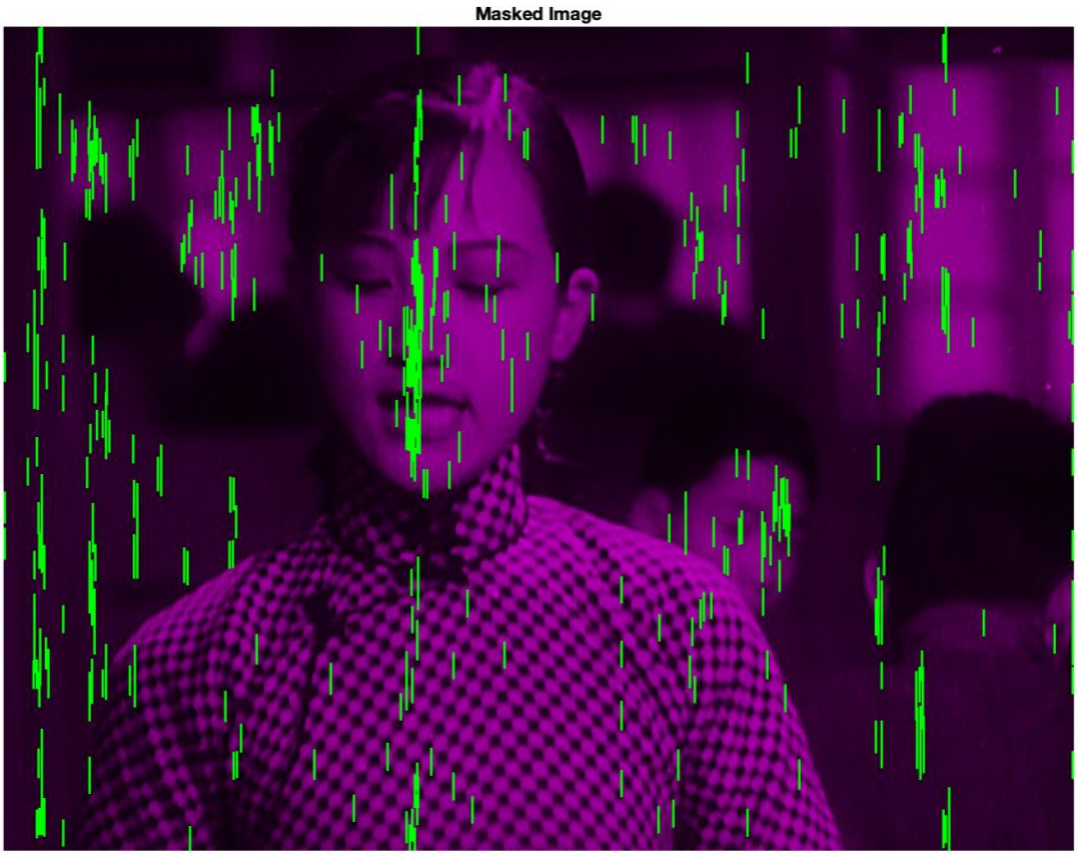
Another dilation operator is used by setting a width threshold of the scratches while maintaining the length of the line. A rectangle of size 17x3 is used as the structuring element. This approach is based on the fact that the scratches range about 3-5 pixels wide. This would get the real size of the line scratches.

$$A \oplus B = \{z \mid (B)_z \cap A \neq \varnothing\}$$



5. Masking

To make the mask of the image, the image is converted to an RGB image where G assigned to the scratches the R and B is assigned to the other pixels that are not detected as a scratch. This will result in a purple background with green line showing the scratches.



Inspiration for this algorithm has been taken from several papers and from lecture slides. One of the recommended solutions is using Hough Transform to detect the lines. This method was taken into consideration; however, it didn't generate as good of the results shown above. The Hough Transform method was disregarded.

3 Task 2: Scratch Removal

In attempt to remove all the scratches detected, an algorithm is implemented so that not only does it remove the scratches, but it also retains and even improve the image quality. The algorithm implemented is linear interpolation. A loop is created that goes through the whole image where it then takes a known pixel before the vertical scratch and a known pixel value after the scratch to create a linear equation. The linear equation is then used to calculate the real pixel values of the scratches. This implementation is made under the assumption that natural images are piecewise smooth with high correlations with adjacent pixels. Knowing this, it is possible to find missing components using linear combination of the surrounding known pixels. Lastly, a 5x5 median filter is applied to remove any noises and smooth the image. Below shows the results and is then compared to the original image side-by-side.

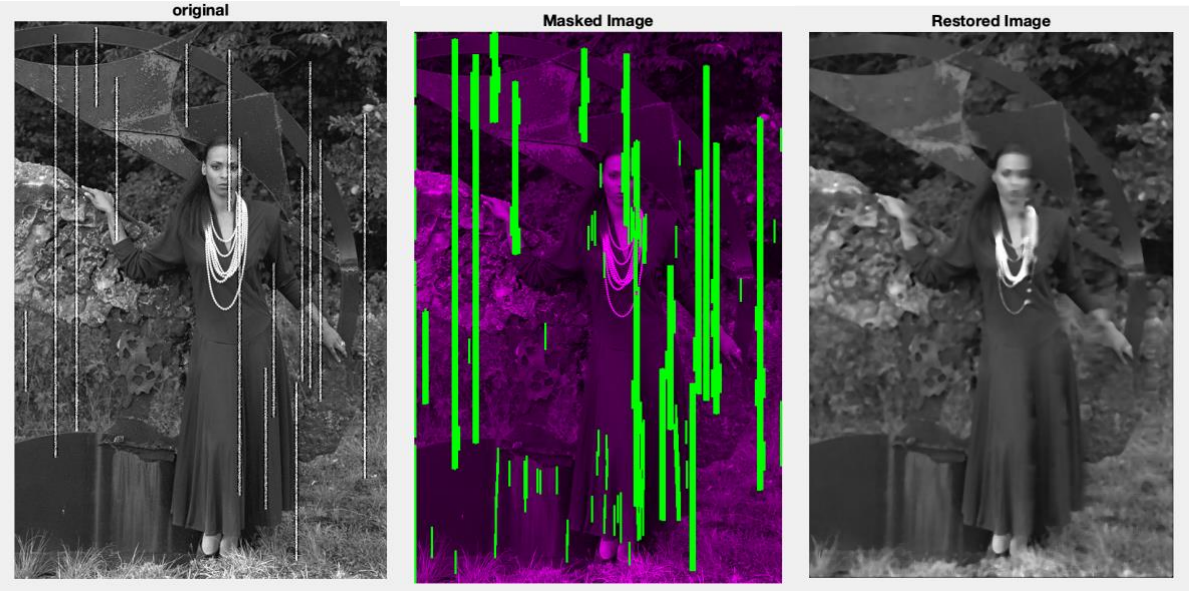
Restored Image

Original

Restored

As a result, we can see that the scratches that were detected were mostly removed.

Below shows the algorithm on synthetic images



4 Conclusion

A common artifact in old films are line scratches. In this project, a vertical line detection algorithm is formulated and was able to detect most of the scratches of an old image. A restoration algorithm is also implemented and can be seen that it has removed majority of the scratches.

4 References

Alasdair Newson, Andrés Almansa, Yann Gousseau, Patrick Pérez. Robust Automatic Line Scratch Detection in Films. 2014. ffhal-00927007

L. Joyeux, O. Buisson, B. Besserer and S. Boukir, "Detection and removal of line scratches in motion picture films," Proceedings. 1999 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (Cat. No PR00149), Fort Collins, CO, USA, 1999, pp. 548-553 Vol. 1, doi: 10.1109/CVPR.1999.786991.

Milady, S & Kasaei, Shohreh & St, Azadi & Germany, Tehran & Iran,. (2004). A New Method for a Fast Detection and Seamless Restoration of Line Scratches in Motion Pictures.

Nie Shiliang, Zhang Hongying, Zhang Liping, Fan Yang and V. Brost, "Vertical scratches detection based on edge detection for old film," 2010 2nd International Conference on Industrial and Information Systems, Dalian, China, 2010, pp. 257-260, doi: 10.1109/INDUSIS.2010.5565861.