Camera Smear Detection

Geospatial Vision and Visualisation

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Overview

Objective

To detect and then generate a binary mask of smear on camera lens from a given sequence of images.

Method

We used OpenCV library and an iterative fitting approach in python to achieve the final image results.

Code:

https://github.com/yuw72/Smear-Detection

Execution:

Run test:

bash runtest.bash

Your own images:

Please refer to readme file.

Our Approach

Preprocessing:

- Improve image contrast and applied gaussian blur to denoise.
- Filter and select less bright images.
- Compute an average grayscale image from image datasets.
- Compute an average image gradient from image datasets.

Our Approach

Smear Segmentation Algorithm:

$$\mathrm{Avg}(|\nabla \mathbf{I}|) \approx \mathrm{Avg}(|\nabla \mathbf{I}_0|) \cdot \mathbf{a}$$

$$\mathrm{Avg}(\mathbf{I}) \approx \mathrm{Avg}(\mathbf{I}_0) \cdot \mathbf{a} + \bar{\mathbf{c}} \cdot \mathbf{b}$$

- Scale both avg image and avg gradient image to 512x512 pixels.
- Use precomputed image average Avg(I) to estimate Avg(I0) by fitting a bivariate polynomial model in a RANSAC fashion.
  - The model is defined as: $\sum_{i=0}^{3} \sum_{j=0}^{3} a_{i,j} x^i y^j$, where x, y are normalized pixel coordinate in [-1,1] x [-1,1].
  - We start from pixels of Avg(I) with top 50% value for least square fitting. Then take the difference between fitted Avg(I0) and Avg(I). Those pixels whose residuals are within a threshold (10%) are considered 'inliers' and used to fit in the next iteration. 'Outliers' are considered dirty spots.
  - We empirically chose 10 iterations considering tradeoff between computation time and accuracy.
  - Repeat the process for the gradient image.
- Compute attenuation and scattering maps.
- We chose a threshold of 0.8 for the binary masks. Values higher than it are labeled 0 and otherwise 1.

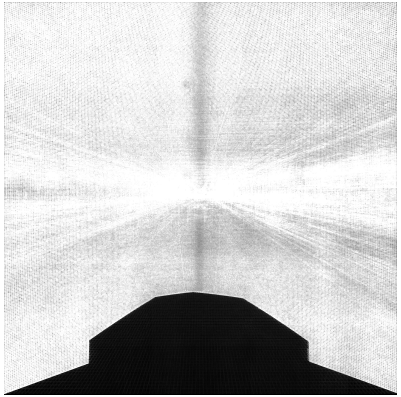
Our Approach

Post-processing:

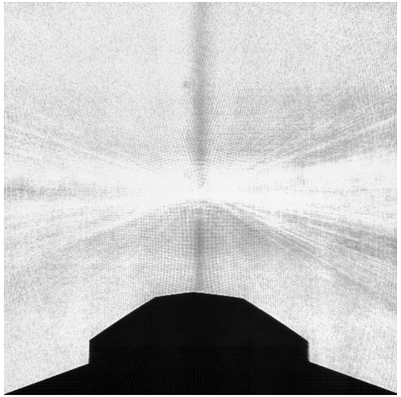
- After the processing, we get a binary mask that is noisy. So we used erosion and dilation to compute a better mask of smear.
- We also validated our approach by the dataset from the paper[1]. The results of ours are very similar to the paper’s results.

Results (Cam 0)

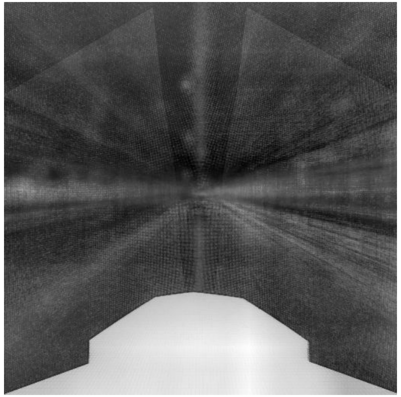
Average Grayscale



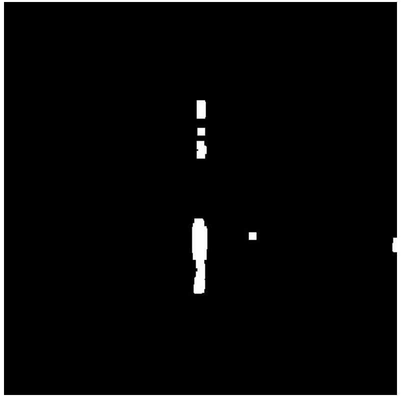
Average Image gradient



Attenuation: **a**(x,y)

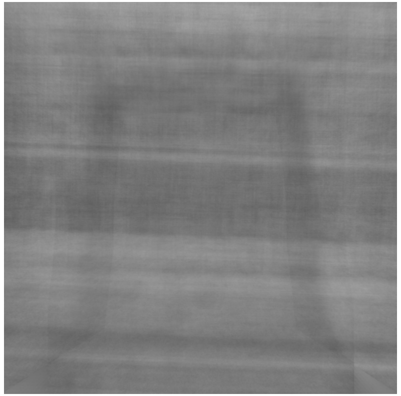


Scattering: **b**(x,y)

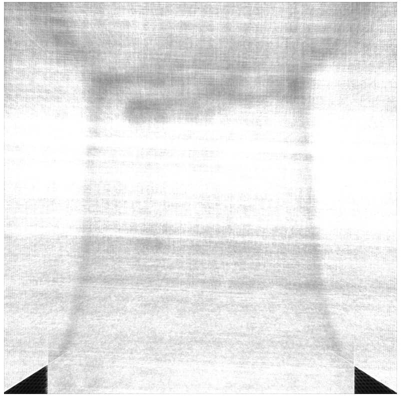


Binary mask

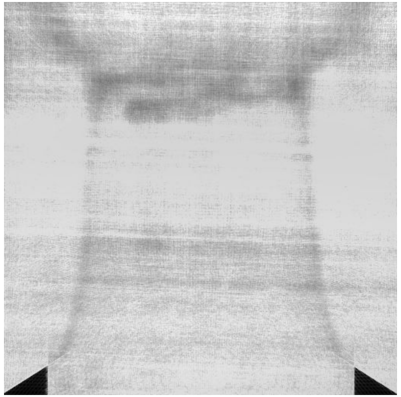
Results (Cam 1)



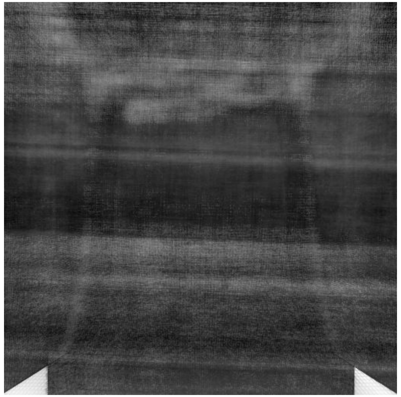
Average Grayscale



Average Image gradient



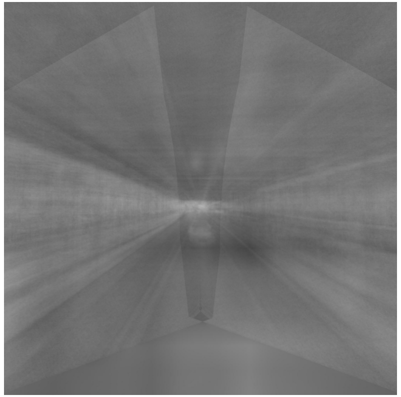
Attenuation: **a**(x,y)



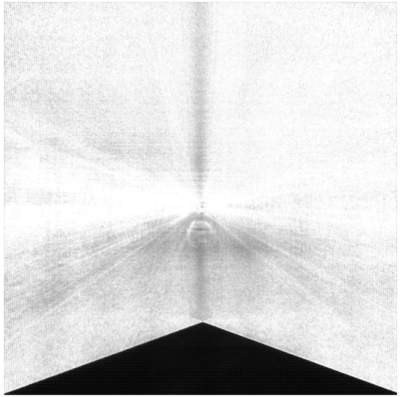
Scattering: **b**(x,y)

Binary mask

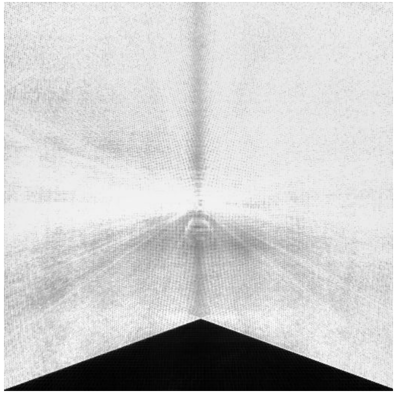
Results (Cam 2)



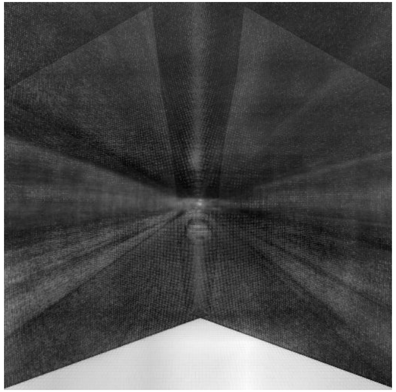
Average Grayscale



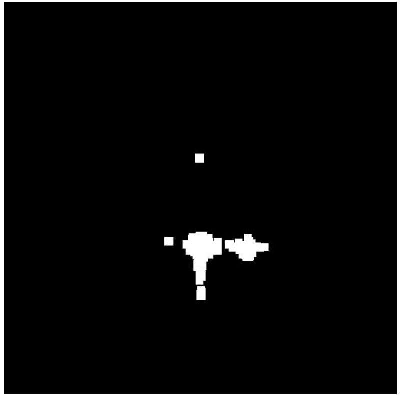
Average Image gradient



Attenuation: **a**(x,y)

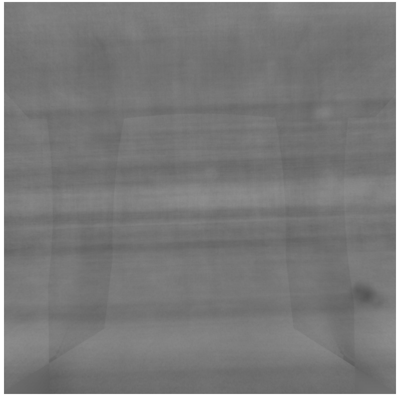


Scattering: **b**(x,y)

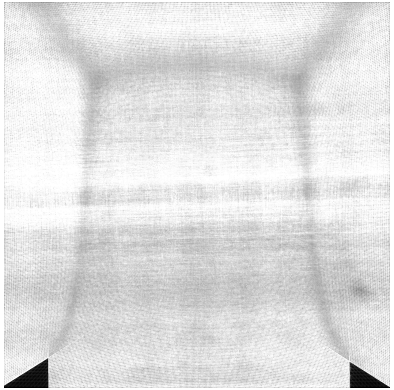


Binary mask

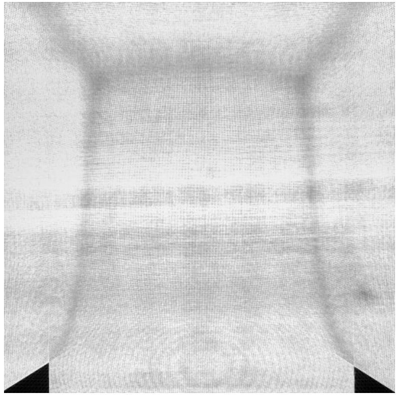
Results (Cam 3)



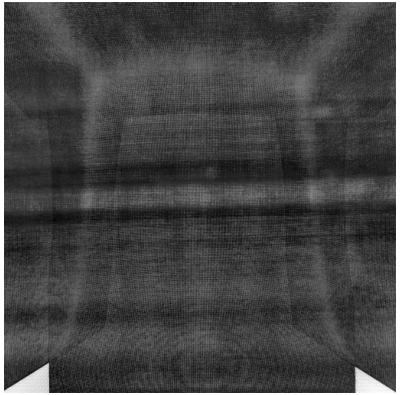
Average Grayscale



Average Image gradient



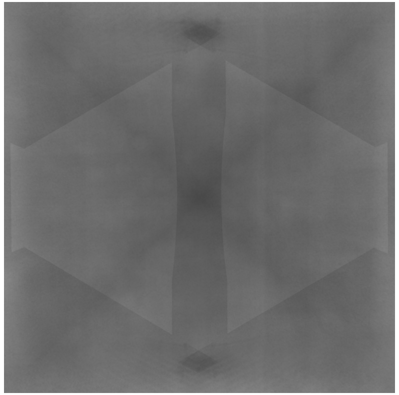
Attenuation: **a**(x,y)



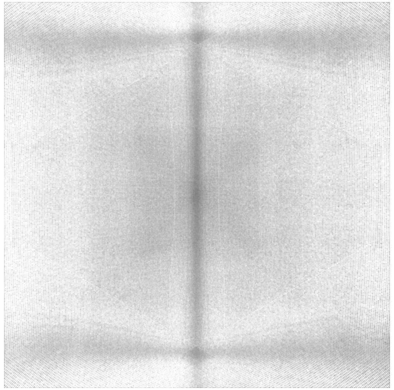
Scattering: **b**(x,y)

Binary mask

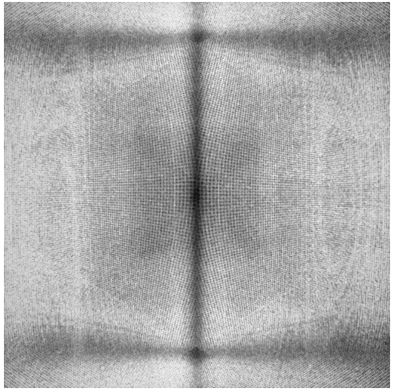
Results (Cam 5)



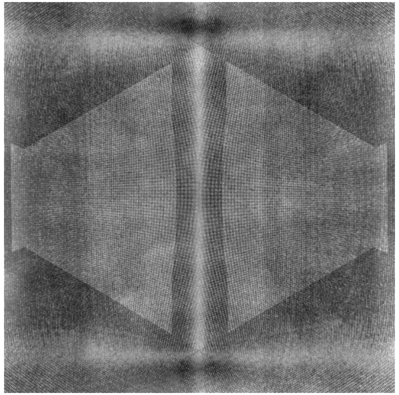
Average Grayscale



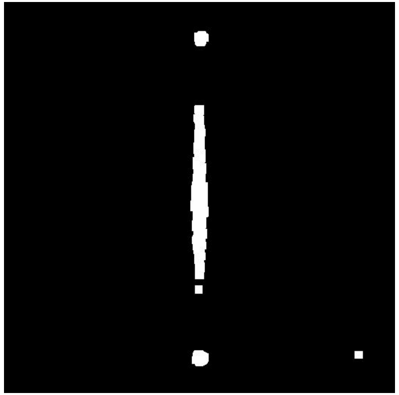
Average Image gradient



Attenuation: **a**(x,y)



Scattering: **b**(x,y)

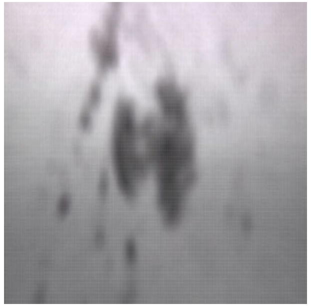


Binary mask

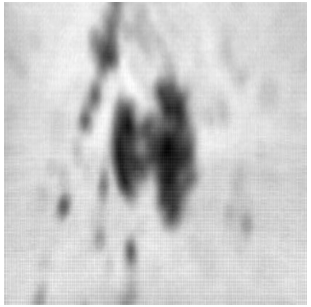
Validation with paper dataset

Source Dataset

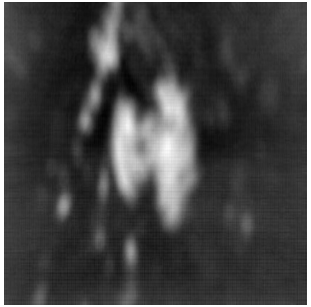
Avg(**I**)



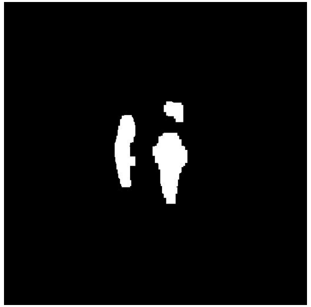
Avg(||grad(**I**)||)



Attenuation: **a**(x,y)



Scattering: **b**(x,y)



Binary mask

Fine Tuning of Our Approach

- Problem

We couldn't detect a clear smear from the given datasets. However, we have successfully detected a clear smear from the image frames in the paper("Removing Image Artifacts Due to Dirty Camera Lenses and Thin Occluders") by using the same approach.

- Solution

The reason must fall into the images we've chosen to get average gray-scale images. Thus, we tried to solve the problem with two methods. First of all, instead of running all images in the given datasets, we decided to keep images with less bright background. Besides, we increase the contrast of images in order to make the smear more obvious.

- Consequence

The accuracy of detecting the smear is improves by visualizing the smear detection images.

Before increasing contrast

After increasing contrast

After that, we repeat the preprocessing technique that finds the average of the gray-scale images and image gradient.

Discussions

Limitations

- Our approach is limited by the images selected, and result may vary depending on how clear the smear is on the images.

Conclusion

- In general, our approach works well on image frames as clear as the ones on paper[1]. Since the dataset is very noisy and smears are not clear in most images, we used other features such as brightness to first filter the ones with greater possibility of carrying a smear, and then increased the image contrast.

Reference

[1] Gu, Jinwei, et al. "Removing image artifacts due to dirty camera lenses and thin occluders." *ACM Transactions on Graphics (TOG)* 28.5 (2009): 1-10.