EE 610: Image Processing

Assignment 2: Image Restoration

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***Abstract*—This report captures the summary of the different image restoration techniques used on blurred and shaky images using space-invariant kernels.**

I. Introduction

The problem statement involved deblurring of images with knowledge of the blur kernel and the assumption that the blur kernel is space inavriant.

II. Background Reading

A. Python Libraries

Matplotlib is a Python library for plotting and displaying graphs and images.

OpenCV is an image processing library which provides a variety of tools. I have only used image loading and saving features to load the image into **numpy** arrays.

Skimage is a Python library with a variety of image processing features out of which I have only used the **compare_ssim** function for calculating the Structural Similarity.

III. Approach

I have implemented 4 main techniques -

- **Full Inverse:** This simply takes the inverse of the transfer function or kernel and applies it in the fourier domain. This fails to work well when the image is noisy, due to the high peaks and variations in the inverse.
- **Truncated Inverse:** We can limit the full inverse in a radius around the center using a low pass filter. I have used an ideal low pass filter but a Butterworth filter would also work well.
- **Wiener Filtering:** It is used to perform linear time-invariant filtering using the kernel and assuming a given noise spectrum.
- **Constrained Least Squares Filtering:** Similar to Wiener filtering but a different waay of balancing the tradeoff between the kernel and noise spectrum.

IV. Discussion

The main challenges faced in this assignment were writing self made functions that ran fast for FFT and inverse FFT. Also, finding optimal values of the parameters for the various kernels was a time-consuming task.

I could not figure out a way to estimate the kernel for the last part of the problem statement where we had to take our own photograph.

The images and results in this report are using the kernel **Kernel1G_SingleTile** and using the first image.

V. Conclusion and Results

As we can see, the images are not very clear with any deblur kernel. This is due to our assumption that the kernel is space-invariant while it was actually not.

This can be verified by changing the kernel to the Cho kernel mentioned on the website, which is a sort of average of all the mini kernels, which gives much better results on deblurring.

The following table consists of the PSNR and SSIM results of the algorithms implemented.

Algorithm	PSNR	SSIM
Full Inverse	28.207	0.079
Truncated Inverse(r=150)	28.877	0.385
Wiener(k=10)	29.030	0.439
Constrained Least Squares (gamma=3.7)	28.493	0.466

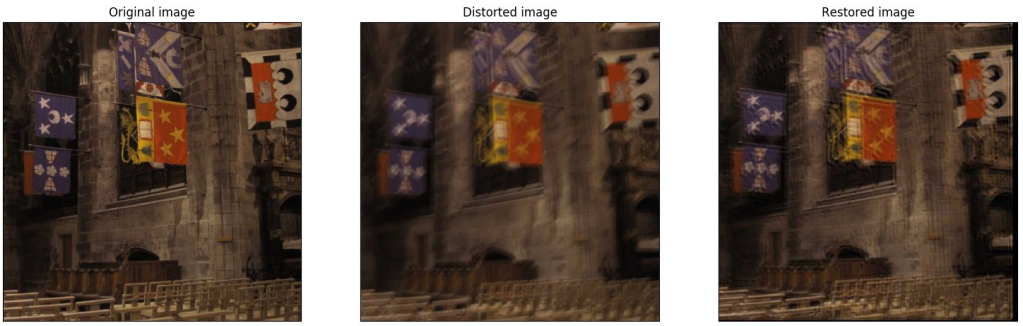
Link to the code on github:

https://github.com/arpan98/EE610-image-restoration

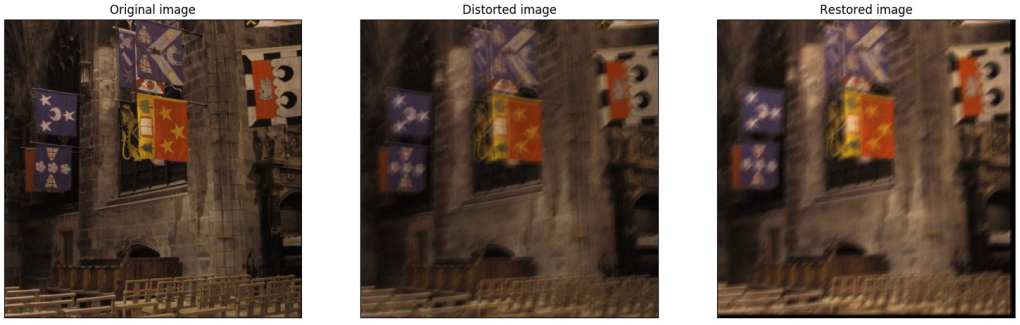
VI. Test Images

Full Inverse

Truncated Inverse with r=150



Wiener with k=10



Constrained Least Squares with gamma=3.7