Image Restoration for License Plate Recognition

DSP Project

Wishnuputra Dhanu

Content

- Introduction
- Implementation
- Result

Introduction

The number of vehicles in our society is keep increasing and hence the number of traffic violations. Therefore traffic surveillance system for recognizing license plate has became very crucial. However capturing license plate of a car that move in a very high speed under bad lighting condition can be a real challenge. Several other factors that might influence the license plate image are illumination, fog, snow, and rain.

Implementation

The implementation of this project is divided into 3 section

- Section 1: Degraded image without noise. Then restored using Inverse Filter and Wiener Filter.
- Section 2: Degraded image with noise. Then restored using Inverse Filter and Wiener Filter.
- Section 3: Restoring real blurred image using Wiener Filter.

The image restoration process are implemented in MATLAB with the support of Image Processing Library. The book, Digital Image Processing 4th Edition by Rafael C. Gonzalez and Richard E. Woods will be the main reference for writing the degradation function, noise function, inverse filter, and wiener filter.

Implementation

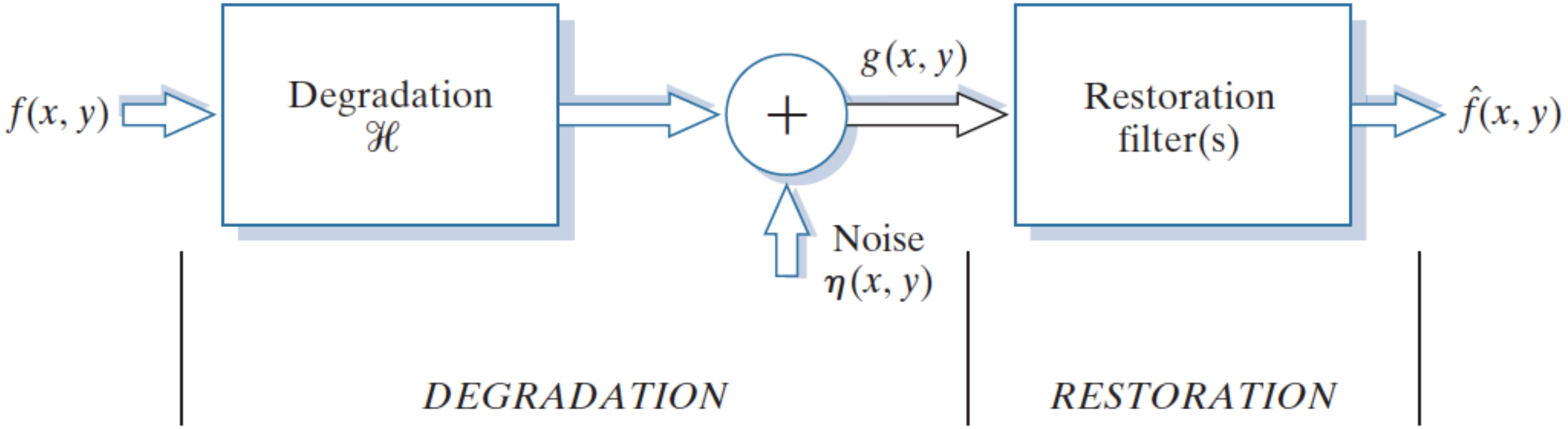
Image Degradation and Restoration Process

The blurred and noisy image which is captured by the surveillance camera could be caused by fast moving vehicle and electric noise of the camera sensor (CCD or CMOS). In order to restore this blurred and noisy image, we need to estimate the degradation and noise function by modeling. After we have estimate the degradation and noise function, then we can perform the restoration by using the Inverse Filter and Wiener Filter.

The diagram in the next slide shows how this process is performed. First we feed in the original image into the degradation function. Secondly, we add noise by feeding in the degraded image into the noise function. Based on the degradation function, we can find the inverse of this function to create the Inverse Filter. Based on the degradation function and noise funtion, we can find the Wiener Filter.

Implementation

Image Degradation and Restoration Process



$$g(x, y) = H[f(x, y)] + \eta(x, y)$$

Implementation

Estimating the Degradation Function

- We estimate the degradation function of the blurred license plate using the motion blur function as below.

- We can estimate the motion blur function if we know the motion variables x(t) and y(t).

$$H(u,v) = \frac{T}{\pi(ua+vb)} sin[\pi(ua+vb)]e^{-j\pi(ua+vb)}$$

Implementation

Inverse Filtering

The simplest technique to restore an image is direct inverse filtering. We can find the restored image by computing the estimate $\hat{F}(u, v)$. This is calculated by dividing the transform of the degraded image with the degradation transfer function.

$$\hat{F}(u, v) = \frac{G(u, v)}{H(u, v)}$$

Implementation

Inverse Filtering

However even if we know the degradation function, we cannot recover the original image. This is exactly because we do not know the noise function $N(u, v)$.

$$G(u, v) = H(u, v)F(u, v) + N(u, v)$$

$$\hat{F}(u, v) = F(u, v) + \frac{N(u, v)}{H(u, v)}$$

Implementation

Wiener Filtering

N. Wiener has first proposed the Wiener filtering method in 1942. This method is one of the earliest and best known approaches for linear image restoration. The *Wiener filter* is also known as the *minimum mean square error filter*. This is because the objective of this method is to estimate $\hat{f}$ of the uncorrupted image f such that the mean square error between them is minimized.

$$e^2 = E\{(f - \hat{f})^2\}$$

where

E = expected value operator

f = undegraded image

Implementation

Wiener Filtering

The solution to the above expression in the frequency domain is

$$\hat{F}(u,v) = \left[\frac{1}{H(u,v)} \frac{|H(u,v)|^2}{|H(u,v)|^2 + S_\eta(u,v)/S_f(u,v)} \right] G(u,v)$$

where

$\hat{F}(u,v)$ = Fourier transform of the estimate of the undegraded image.

$G(u,v)$ = Fourier transform of the degraded image.

$H(u,v)$ = Degradation transfer function

$S_\eta(u,v) = |N(u,v)|^2$ = Power spectrum of the noise

$S_f(u,v) = |F(u,v)|^2$ = Power spectrum of the undegraded image

Implementation

Signal to Noise Ratio (SNR)

Signal to noise ratio gives information about the ratio of signal power of the original image to the level of noise power. Image with low noise will have higher SNR compared to image with high noise. This ratio have a significant role in improving the performance of the image restoration process.

$$SNR = \frac{\sum_{u=0}^{M-1} \sum_{u=0}^{N-1} |F(u,v)|^2}{\sum_{u=0}^{M-1} \sum_{u=0}^{N-1} |N(u,v)|^2}$$

Results

Section 1 - Image Restoration on Blurred License Plate (without noise)

In this section we will degrade the original image using motion filter with below parameters:

- motion length = 10, motion angle = -10
- motion angle = 50 and motion angle = -15

We will then restore the image using Inverse Filter and Wiener Filter. Then we will compare the image results.

Results

Section 1 - Image Restoration on Blurred License Plate (without noise)

Degradation function is motion blur with motion length = 10 and motion angle = -10.

Original Image

Degraded Image

Results

Section 1 - Image Restoration on Blurred License Plate (without noise)

Restoring the degraded image using Inverse Filter

Degraded Image

Restored Image using Inverse Filter

Results

Section 1 - Image Restoration on Blurred License Plate (without noise)

Restoring the degraded Image using Wiener Filter with SNR (Signal to Noise Ration) = 0

Degraded Image

Restored Image using Wiener Filter

Results

Section 1 - Image Restoration on Blurred License Plate (without noise)

Degradation function is motion blur with motion length = 50 and motion angle = -15.

Original Image

Degraded Image

Results

Section 1 - Image Restoration on Blurred License Plate (without noise)

Restoring the degraded image using Inverse Filter

Degraded Image

Restored Image using Inverse Filter

Results

Section 1 - Image Restoration on Blurred License Plate (without noise)

Restoring the degraded Image using Wiener Filter with SNR (Signal to Noise Ration) = 0

Degraded Image

Restored Image using Wiener Filter

Results

Section 1 - Image Restoration on Blurred License Plate (without noise)

The image restoration results of both Inverse Filter and Wiener Filter are similar. This is due to the fact that there is no noise added to the degraded image. Therefore the Inverse Filter perform as good as the Wiener Filter.

Results

Section 2 - Image Restoration on Blurred License Plate (with noise)

In this section we will degrade the original image using motion filter with below parameters:

- motion length = 10, motion angle = -10, noise type = gaussian, noise mean = 0, noise variance = 1e-7
- motion angle = 50 and motion angle = -15, , noise type = gaussian, noise mean = 0, noise variance = 1e-6

We will then restore the image using Inverse Filter and Wiener Filter. Then we will compare the image results.

Results

Section 2 - Image Restoration on Blurred License Plate (with noise)

Degradation function is motion blur with motion length = 10 , motion angle = -10. The noise type is gaussian with noise mean = 0, noise variance = 1e-7

Original Image

Degraded Noisy Image

Results

Section 2 - Image Restoration on Blurred License Plate (with noise)

Restoring the degraded image using Inverse Filter

Degraded Noisy Image

Restored Image using Inverse Filter

Results

Section 2 - Image Restoration on Blurred License Plate (with noise)

Restoring the degraded Image using Wiener Filter with

SNR = 1.2988e-06

Degraded Noisy Image

Restored Image using Wiener Filter

Results

Section 2 - Image Restoration on Blurred License Plate (with noise)

The Inverse Filter is struggling to restore the image properly. This is because there is noise added to the image. In this situation the Wiener Filter perform much better in restoring the details of the image.

Results

Section 2 - Image Restoration on Blurred License Plate (with noise)

Degradation function is motion blur with motion length = 30 , motion angle = -15. The noise type is gaussian with noise mean = 0, noise variance = 1e-5

Original Image

Degraded Noisy Image

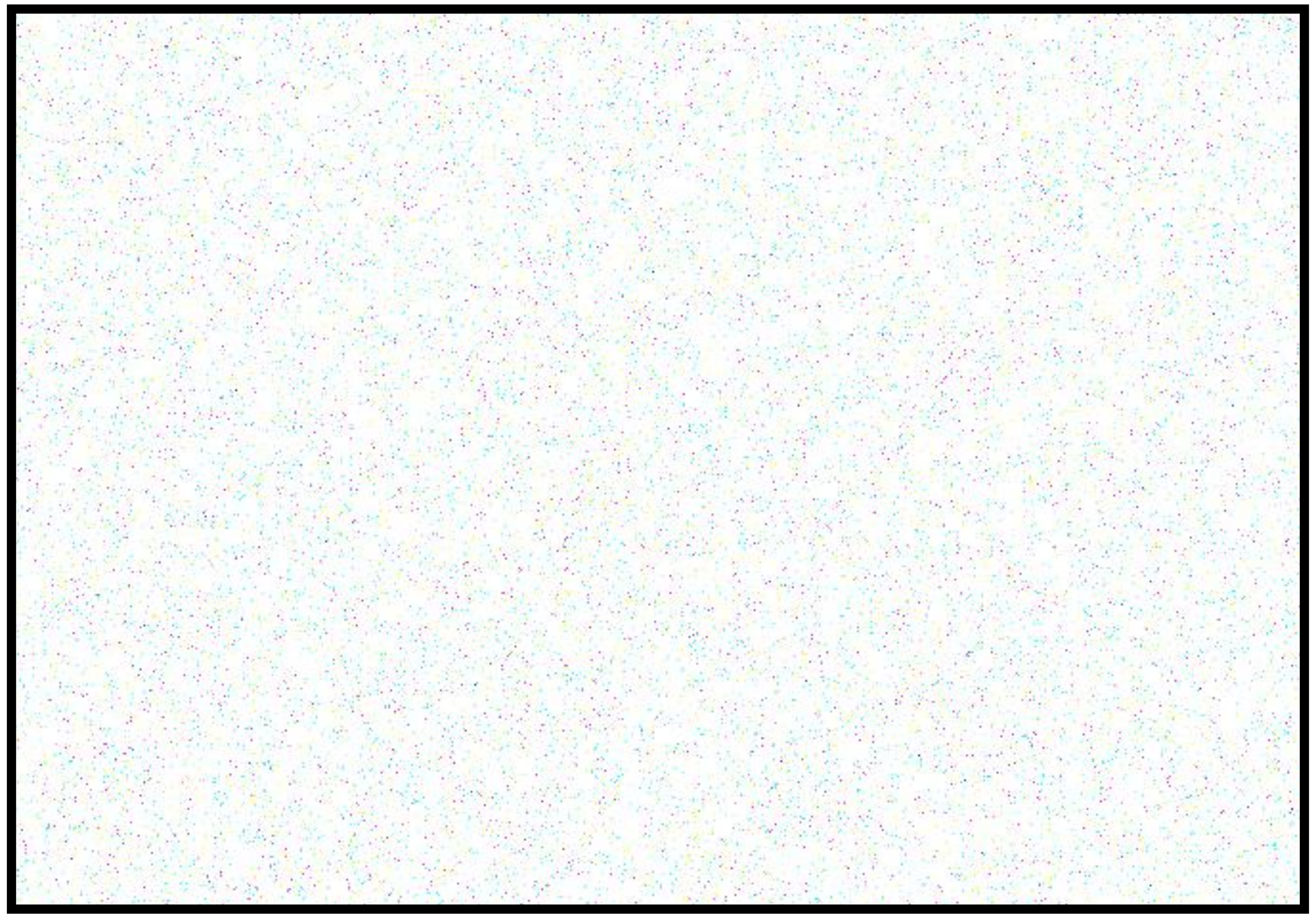
Results

Section 2 - Image Restoration on Blurred License Plate (with noise)

Restoring the degraded image using Inverse Filter

Degraded Noisy Image

Restored Image using Inverse Filter



Results

Section 2 - Image Restoration on Blurred License Plate (with noise)

Restoring the degraded Image using Wiener Filter with

SNR = 1.2988e-04

Degraded Noisy Image

Restored Image using Wiener Filter

Results

Section 2 - Image Restoration on Blurred License Plate (with noise)

When we set higher noise variance, the Inverse Filter in this case doesn't able to restore the image at all. While the Wiener Filter is able to restore the image, even though there is some visible noise.

Results

Section 3 - Restoring Real Blurred Image

In this section we will restore the image of a blurred license plate. The image was taken at Prato della Valle. The image on the left was taken when the car was moving at a high speed in the evening. The image on the right was taken when the car was stop. The goal is to restore the blurred image, therefore it can shows the license plate number clearly which is FA 660RL.

Results

Section 3 - Restoring Real Blurred Image

In order to restore the blurred image, we need to find the degradation function that best described the motion blur effects in the image. This can be achieved by fine tuning the parameter of the degradation function and noise function.

We will use Wiener Filter to restore the blurred image. The parameter that we will fine tune are motion length, motion angle, and SNR (Signal to Noise Ratio). After fine tuning these parameters, we are able to restore the blurred image as shown in the next slide.

Results

Section 3 - Restoring Real Blurred Image

Restoring the blurred image using Wiener Filter with parameter as follows. motion length = 21.3, motion angle = 7.3, and SNR = 0.05. The license plate of the restored image is now readable compared to the original image

Original Image

Restored Image