IMAGE RESTORATION
USING
WIENER FILTER AND CONSTRAINT LEAST SQUARE FILTER

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1. Abstract.

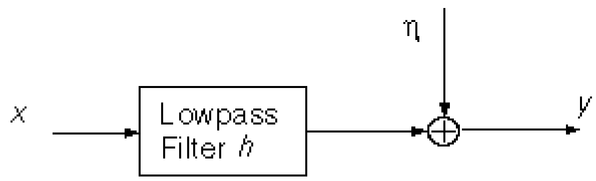
The purpose of image restoration is to "compensate for" or "undo" defects which degrade an image. All natural images when displayed have gone through some sort of degradation. Degradation comes in many forms such as motion blur, noise, and camera misfocus. The most straightforward and a conventional technique for image restoration is deconvolution, which is performed in the frequency domain and after computing the Fourier_transform of both the image and the PSF and undo the resolution loss caused by the blurring factors. In this project, few methods are introduced and are implemented in the image processing to restore images.

2. Introduction.

Image restoration is the operation of taking a corrupt/noisy image and estimating the clean, original image. Corruption may come in many forms such as_motion blur, noise and camera mis-focus. Image restoration is different from image enhancement. The objective of image restoration techniques is to reduce noise and recover resolution loss Image processing techniques are performed either in the image domain or the frequency domain.

3. Degradation Model.

The block diagram for our general degradation model is



where *g* is the corrupted image obtained by passing the original image *f* through a low pass filter (blurring function) *b* and adding noise to it. We present different ways of restoring the image.

4. **Methodology.**

There are various methods of Image Restoration. In this two methods have been used for Image Restoration and these are as follows:

a. Wiener Filter
b. Constraint Least Square Filter

4.1 **Wiener Filter.**

Wiener filter is a filter used to produce an estimate of a desired or target random process by linear time-invariant (LTI) filtering of an observed noisy process, assuming known stationary signal and noise spectra, and additive noise. The Wiener filter minimizes the mean square error between the estimated random process and the desired process. In Image Processing the Wiener filter is used to remove noise from a picture.
The Wiener filtering is a linear estimation of the original image. The approach is based on a stochastic framework. The orthogonality principle implies that the Wiener filter in Fourier domain can be expressed as follows:

$$W(f_1, f_2) = \frac{H^*(f_1, f_2) S_{xx}(f_1, f_2)}{|H(f_1, f_2)|^2 S_{xx}(f_1, f_2) + S_{\eta\eta}(f_1, f_2)},$$

where $S_{xx}(f_1, f_2)$, $S_{\eta\eta}(f_1, f_2)$ are respectively power spectra of the original image and the additive noise, and $H(f_1, f_2)$ is the blurring filter. It is easy to see that the Wiener filter has two separate part, an inverse filtering part and a noise smoothing part. It not only performs the deconvolution by inverse filtering (highpass filtering) but also removes the noise with a compression operation (lowpass filtering).

4.2 **Least Constraint Square Filtering.**

CLS filter and it's variants is probably one of the most common utilized restoration filter. It simply turns an unconstrained least square of optimization problem into a constrained one. It restricts the solution space of the least squares approach, by incorporating into the problem of prior knowledge about the solution. Bases optimality of restoration on a measure of smoothness. Seek minimum of a criterion function

$$C = \sum_{x=0}^{M-1} \sum_{x=0}^{N-1} [\nabla^2 f(x, y)]^2$$ (second derivative)

From the degradation system we get

$$g(x, y) = h(x, y) * f(x, y) + \eta(x, y)$$

$g = Hf + \eta$ (vector-matrix form)

The criterion function is subject to the constraint

$$\left\| g - H\hat{f} \right\|^2 = \|\eta\|$$

where f' is an estimate of the undegraded image. The frequency domain solution thus becomes

$$\hat{F}(u, v) = \left[\frac{H*(u,v)}{|H(u,v)|^2 + \gamma|P(u,v)|^2}\right] G(u, v)$$

where γ is the parameter to be adjusted (γ = 0 ⇒ inverse filtering), and P(u, v) is the fourier transform of the function.

5. Tables.

Method	PSNR
Noisy blurred image	25.002
Self Tuned Wiener restoration	26.00
Wiener restoration	27.968
Pseudo-Inverse	22.024
Unsup.Wiener	26.498

6. Conclusion.

In image restoration, we must use some method of restoration which would trade off inverse filtering with de-noising. Wiener filtering is the optimal tradeoff between the inverse filtering and noise smoothing. This is the main task in making the Wiener filtering work well in practice. Constrained least squares filter for deconvolution followed by denoising section, deblurred image obtained after deconvolution and decomposed into texture and cartoon parts, using curvelet transform, which are then denoised using wave atom transform and wavelet transform respectively. This method does not require a priori knowledge of the noise distribution and provides effective noise reduction for texture dominant images.