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Hybrid Approach for Denoising of Degraded Images

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***Abstract*—Denoising of images using hybrid approach has been a predominant scenario in the current trends. The hybrid approach refers in giving up a combined framework to utilize the advantage of both Fourier and wavelet domain schemes. The noisy images including their Region of Interest (ROI) can yield encouraging results, when obtained through the proposed hybrid approach when comparing to the single transform domain method. Thus the motivation for the hybrid method has been the realization that shrinkage in single transform cannot yield good estimates in deconvolution problems. The main focus of this paper is denoising of degraded images in which the blurring operator inversion is followed by noise attenuation through scalar shrinkage in both the Fourier and wavelet domain. The Fourier shrinkage utilizes the structure of the noise inherent in deconvolution. While the wavelet shrinkage utilizes the piecewise smooth structure of real-world signals and images. The advantage of denoising in Fourier domain is the ability to deal with overlapping responses. But in some exceptions when Fourier domain is alone used, noise amplification might be a disadvantage. Noise can be reduced in the frequency domain by shrinking the frequency coefficients, but noise and signal may be difficult to separate. Wavelet transforms have advantages over traditional Fourier transforms for representing functions that have discontinuities and sharp peaks, and for accurately reconstructing finite, non-stationary signals. Hence in this paper it is solved by using the combined Fourier and Wavelet shrinkage.**

***Keywords*—Deconvolution, Fourier domain, Wavelets, Restoration, Smoothness, Estimation.**

I. INTRODUCTION

Deconvolution is a recurring theme in a wide variety of signal and image processing problems. For example, practical satellite images are often blurred due to limitations such as aperture effects of the camera, camera motion, or atmospheric turbulence. Deconvolution is needed when we wish a crisp deblurred image for viewing or further processing. The desired signal x is input to a known linear time-invariant (LTI) system H having impulse response h. Independent Identically Distributed (IID) samples of Gaussian noise **γ** with variance σ^2 corrupt the samples of a system.

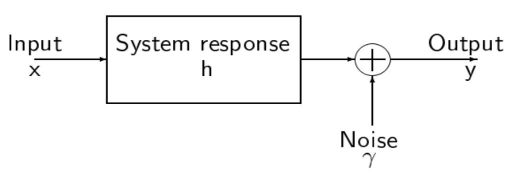

Fig. 1 Convolution Model

Given the system,

$$y(t) = h(t) * x(t) + \gamma(t)$$

Where * denotes convolution
x(t) is input signal at time t.
h(t) is the known impulse response of a linear time-invariant system.
γ(t) is some unknown additive noise
y(t) is our observed signal

Traditionally, the Fourier domain is used to estimate x(t) from $\tilde{x}$(t). The strength of the Fourier basis is that it most economically represents the colored noise. However, the weakness of the Fourier domain is that it does not economically represent signals with singularities such as images with edges. Recently, the wavelet domain has been exploited to estimate x(t) from $\tilde{x}$(t). The strength of the wavelet domain is that it economically represents classes of signals containing singularities that satisfy a wide variety of local smoothness constraints, including piecewise smoothness class.

II. RELATED WORK

Allen D. Hillary [1] investigates an iterative procedure called as iterative wiener filter, which successively uses the wiener filtered signal as an improved prototype to update the covariance estimates.

Ramesh Neelamani, H. Choi [2] proposes a new approach to wavelet-based image deconvolution that comprises Fourier-domain system inversion followed by wavelet-domain noise suppression. It employs an algorithm called regularized inverse filter, which allows it to operate even when the system is non-invertible. Using a mean-square-error metric, it strikes an optimal balance between Fourier-domain regularization that is matched to the system and wavelet-domain regularization that is matched to the input signal.

R. Neelamani [3] focuses an efficient, hybrid Fourier-wavelet regularized deconvolution (ForWaRD) algorithm that performs noise regularization via scalar shrinkage in both the Fourier and wavelet domains. The Fourier shrinkage exploits the Fourier transform's economical representation of the colored noise inherent in deconvolution, whereas the wavelet shrinkage exploits the wavelet domain's economical representation of piecewise smooth signals and images.

III. MOTIVATION OF THE FIELD

Apart from the several techniques in image processing, the image filtering process is a rapidly evolving field with growing real time applications. Removal of noise from a signal is an important problem in image and signal processing. Noise is a practical problem raised in many fields such as satellite, medical and seismology. Hence the noise filtering becomes necessary to remove the noise and unwanted distortions such as Gaussian noise, impulse noise, and mix of Gaussian and impulse noise. Because of their wide application, the filtering is of great importance in signal and image processing.

IV. OVERVIEW OF IMAGE FILTERING

The need for efficient image restoration methods has grown with the massive production of digital images often taken in poor conditions. No matter how good cameras are, an image improvement is always desirable to extend their range of action.

The purpose of image restoration is to reconstruct an unobservable true image from a degraded observation. An observed image can be written, ignoring additive noise, as the two-dimensional convolution of the true image with a linear space-invariant LSI blur, known as the PSF (Point Spread Function). Restoration in the case of known blur, assuming the linear degradation model, is called linear image restoration and it has been presented extensively in the last three decades giving rise to a variety of solutions. In many practical situations, however, the blur is unknown. Hence, both blur identification and image restoration must be performed from the degraded image.

A. *Noise Model*

Any real world sensor is affected by a certain degree of noise, whether it is thermal, electrical or otherwise. This noise will corrupt the true measurement of the signal, such that any resulting data is the combination of signal and noise. Common noise models summarizes in Table **1.**

Noise	Description
Gaussian Noise	Statistical noise that has its probability density function equal to that of the normal distribution
Salt and pepper Noise	Defining characteristic is that the color of noisy pixels bears no relation to the color of surrounding pixels.
Poisson Noise	Amount of photons per pixel value.
Speckle Noise	Modelled as a multiplicative noise

Table 1: Different Noise models

B. Concepts of Noise Filtering

Noise filtering is the core operation in computer vision applications. Images taken with both digital cameras and conventional film cameras will pick up noise from a variety of sources. Noise filtering is a powerful tool to remove the noise present in the images in order to do further processing – for artistic work or marketing or medical analysis or for practical purposes.

Noise reduction is the process of removing noise from a signal such as eliminating the unwanted distortions and omitting out-of-focus areas in the image. Filters are powerful tools to recover a true signal from incomplete, indirect or noisy data.

V. PROPOSED HYBRID FILTERING METHOD

A. Function of Fourier domain based Filter

The goal of the Fourier domain based filter is to filter out noise that has corrupted a signal. Important characteristics of the Fourier based filtering are:

1. Assumption: Signal and noise are stationary linear stochastic processes with known spectral characteristics or known autocorrelation and cross-correlation.
2. Requirement: the filter must be physically realizable, i.e. Causal.
3. Performance criterion: Minimum Mean-Square Error (MMSE).

From the definition, to find g(t) we have

$$\hat{x}(t) = g(t) * y(t)$$

The Wiener deconvolution filter provides g(t). Then filter is most easily described in the frequency domain:

$$G(f) = H^*(f)\, S(f) \,/\, |H(f)|^2\, S(f) + N(f)$$

Where

G(f) and H(f) are the Fourier transforms of g and h, respectively at frequency f.

S(f) is the mean power spectral density of the input signal x(t).

N(f) is the mean power spectral density of the noise.

γ(t) and * denotes complex conjugation.

B. Restoration Formula

$$\tilde{F} = GH^*/|H|^2 + \gamma$$

Where,

$\tilde{F}$ - Fourier transform of the restored image

H*- Complex conjugate of Fourier Transform of Point Spread Function.

G- FourierTransform of the degraded image γ- noise to signal energy ratio

C. Image Deconvolution

Deconvolution is a process used to reverse the effects of convolution on recorded data. The concept of deconvolution is widely used in the techniques of signal and image processing.

VI. BACK-GROUND ON WAVELETS

A. Wavelets

Wavelets are mathematical functions that cutup data into different frequency components, and then study each component with a resolution matched to its scale. Wavelets refers to the representation of a signal in terms of a finite length or fast decaying oscillating waveform. Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other functions. This waveform is scaled and translated to match the input signal. Wavelet transforms are based on small waves called wavelets of varying frequency and limited duration.

B. Daubechies wavelet

Daubechies wavelets are a family of orthogonal wavelets which are chosen to have the highest number 'p' of vanishing moments for given support N=2p, and among the 2^{p-1} possible solutions the one is chosen whose scaling filter has external phase.moments. With each wavelet type of this class, there is a scaling function which generates an orthogonal multiresolution analysis. In general the Daubechies wavelets (D2-D20) are commonly used. The index number refers to the number of coefficients. Each wavelet has a number of zero moments or vanishing moments equal to half the number of coefficients. A vanishing moment refers to the wavelets ability to represent polynomial behaviour or information in a signal.

Daubechies wavelets are widely used in solving a broad range of problems, e.g. self-similarity properties of a signal or fractal problem, signal discontinuities, etc.

VI. EXPERIMENTAL RESULTS

The Qualitative work on restored image is illustrated by the following figures.

Fig.2 Blurred Image

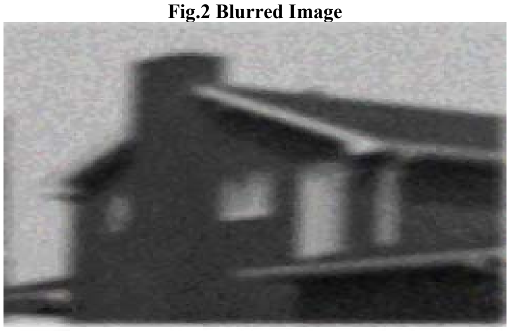

Fig.3 Blurred + Noisy Image

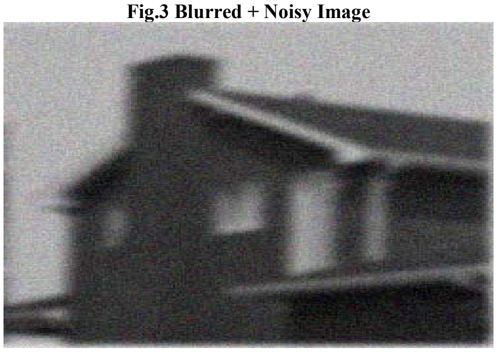

Fig.4 Filtered Image
(Fourier domain filtering technique – Wiener Filter)

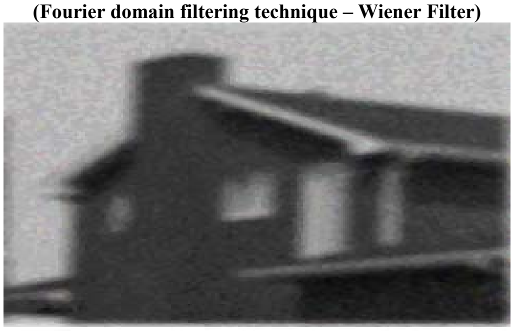

Fig.5 Blurred + Noisy Image

Fig.6 Filtered Image by Hybrid Method (Fourier + wavelet)

VII. CONCLUSION

In this study, the image noise filtering process is vital part of many image and signal processing applications. In our paper, we considered the degraded image(Blurred + noisy image) as shown in Fig 3. The image is subjected to Fourier domain based filter such as Wiener filter. The visual quality of this image is shown in Fig 4. In this Proposal we are appropriately combining Fourier domain filtering method with Daubechies wavelet and we successively remove the smoothening effect of the image. The filtered image by hybrid method is shown in Fig.6. From the comparison results, we proved that our estimated filtering technique (Hybrid approach) can provide an effective removal of any kind of bursts (noises) and outperforms existing Fourier domain based filtering technique in terms of image quality.

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BIOGRAPHY

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