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Despeckling of Images Using Wiener Filter in Dual Wavelet Transform Domain

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Abstract -Removal of noise from an image is still a challenging problem in image processing research area. In this paper comparison of two denoising method using adaptive wiener filter and fuzzy filter in wavelet domain is done. Wavelet transforms are specially used for compression, Denoising, Thresholding, Error reduction, reconstruction, and for image synthesis[8]. Discrete wavelets transform and filters are used for image reconstruction in experiments. Performance can be calculated on the basis of two parameter i.e PSNR (peak signal-to-noise ratio) & RMSE(root mean square error). MATLAB is used for implementation of two method.

INTRODUCTION

Removal of noise from an image is an essential part of image processing systems [1]. An image is always affected by noise in its capture, acquisition and processing[9]. Hence to improve its visual quality denoising is done. Basically the image quality is measured by the peak signal-to-noise ratio (PSNR) and root mean square error (RMSE) [2]. Noise may be classified as substitutive noise (impulsive noise: e.g., salt and pepper noise, random valued impulse noise, etc.), additive noise (e.g., additive white gaussian noise) and multiplicative noise (e.g. speckle noise). However, in this paper the investigation has been done in salt & pepper, gaussian noise, poisson noise & speckle noise. In general, the goal of any noise removal scheme is to suppress noise as well as to preserve details and edges of image as much as possible. Wavelet decomposes the image and separate noisy signal from original signal on appropriate basis in [1]. Figure [1] shows the basic model for denoising of image. In such model first image is taken and some noise is added to image to make it as noisy image and then noisy image is decomposed by wavelet transform then using thresholding to shrink decomposed image & apply hybrid filter (Fuzzy and wiener filter respectively) to remove noise from noisy image and at last denoised image can be obtained by applying inverse wavelet transform (idwt). The performance parameter between the noisy image and denoised image can be calculated in terms of PSNR[10] and RMSE. Our aim is to reduce RMSE and to increase PSNR (peak signal to noise ratio) of an denoised image as much as possible. It will enhance the visual quality of the image while preserving the edges and other details of the image.

DISCRETE WAVELET TRANSFORM

Image Reconstruction with Discrete wavelet transform[11] used 2D version of the analysis and synthesis filter banks. In the 2D (image) case, the 1D analysis filter bank is first applied to the columns of the image and then applied to the rows. The method relies on two measures. The first is a classic measure of smoothness of the image and is based on an approximation of the local Holder exponent via the wavelet coefficients. The second, novel measure takes into account geometrical constraints, which are generally valid for natural images. The smoothness measure and the constraints are combined in a Bayesian probabilistic formulation, and are implemented as a Markov random field (MRF) image model. The manipulation of the wavelet coefficients is consequently based on the obtained probabilities.

A. Wiener Filtering

The purpose of the Wiener filter is to filter out the noise that has corrupted a signal. This filter is based on a statistical approach. Mostly all the filters are designed for a desired frequency response. Wiener filter deal with the filtering of an image from a different view. The goal of wiener filter is reduced the mean square error as much as possible. This filter is capable of reducing the noise and degrading function. One method that we assume we have knowledge of the spectral property of the noise and original signal. We used the Linear Time Invariant filter which gives output similar as to the original signal as much possible [3]. It uses the following Function

J = wiener2(I, [m n], noise)[7]
Filters the image I using pixelwise adaptive Wiener filtering, using neighborhoods of size m-by-n to estimate the local image mean and standard deviation. If you omit the [m n] argument, m and n default to 3. The additive noise (Gaussian white noise) power is assumed to be noise.

B. Fuzzy Filter

Fuzzy filter removes noise based on fuzzy sets. It is basically used to reduce RMSE from an noisy image. Fuzzy filter is similar to median filter but it also uses triangular function. It uses the following functions to reduce noise level from an image
[Y] = ATMAV(X, h)[7]
X is noisy image, y is de-noised image and F is window function or weighting function.

C. Proposed Filter Method

In this paper hybrid filter i.e combination of two filter is used to improve the visual quality of an image. Fuzzy filter

is followed by wiener filter. The experimental results will show the calculation of PSNR and RMSE.
The experiment are performed using matlab and image processing toolbox. The pictorial representation of such experiment are shown in Figure1.

(a)Original image

(b)Noisy image(gaussian noise at variance = 0.04)

(c)Denoised image(Filterd by Fuzzy + Wiener)

Figure 1. Denoising using two filters(Fuzzy and Wiener)

The following experiment in terms of PSNR and RMSE are shown in table1.

Table 1. Performance Comparisons Using Hybrid Filter in Wavelet Domain at Dog.jpg in different noise variance taking additive white gaussian noise

Noise variance	Noisy image PSNR	Denoised image PSNR	Noisy image RMSE	Denoised image RMSE
0.01	20.3201	28.4198	24.5772	9.6728
0.02	17.4417	27.1689	34.2337	11.1711
0.03	15.7733	26.4580	41.4833	12.1238
0.04	14.6905	25.8197	46.9909	13.0484
0.05	13.8002	25.0599	52.0629	14.2412
0.10	11.4582	22.8069	68.1761	18.4585
0.15	10.3084	21.2908	77.8252	21.9786

RESULT AND CONCLUSION

The experiment shows that if wiener and fuzzy is combined then it shows better result in both context i.e in visualization and in terms of RMSE and PSNR in table 2.

Table 2. Performance Comparisons Between Fuzzy, Wiener & Hybrid Filter in Wavelet Domain at Dog.jpg in different noise variance taking additive white gaussian noise

Noise var	Fuzzy Filter		Wiener Filter		Proposed Filter	
	RMSE	PSNR	RMSE	PSNR	RMSE	PSNR
0.01	10.236	27.927	9.615	28.471	9.672	28.419
0.02	11.719	26.752	11.426	26.972	11.171	27.168
0.03	12.844	25.956	12.971	25.870	12.123	26.458
0.04	13.948	25.240	14.493	24.907	13.048	25.819
0.05	14.878	24.679	15.892	24.107	14.241	25.059
0.10	19.679	22.250	21.053	21.664	18.458	22.806
0.15	22.971	20.907	24.620	20.305	21.978	21.290

This paper concludes that hybrid filter shows better results in comparison with filter using alone. This experiment is limited up to Gaussian noise. In future if combinations of different filter will be taken on different noises then better results can be achieved.

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