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An Efficient Image Denoising System

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Abstract— The aim of this dissertation work is related to the pre-processing of an image before using it in applications. The pre-processing is done by denoising of image. In order to achieve this, combination of Image denoising algorithms WT (Wavelet transform) and KLT (Karhunen-Loeve transform) and an adaptive filter are applied on images to remove the noise that are either present in the image during capturing or injected into the image during transmission. The WT (Wavelet transform) has an excellent performance in the denoise field while KLT shows a good performance in the signal reconstructed ability and adaptive filter can further enhance the image by filtering out the Gaussian noise. In this work PSNR and MSE parameters are being improved using combination of WT (Wavelet transform), KLT (Karhunen-Loeve transform) and adaptive fillter.

Keywords— WT (Wavelet transform), KLT (Karhunen-Loeve transform) , Adaptive filter, Image processing, Noise, Denoising.

I. INTRODUCTION

A very large portion of digital image processing is devoted to image restoration. This includes research in algorithm development and routine goal oriented image processing. Image restoration is the removal or reduction of degradations that are incurred while the image is being obtained. Degradation comes from blurring as well as noise due to electronic and photometric sources. Blurring is a form of bandwidth reduction of the image caused by the imperfect image formation process such as relative motion between the camera and the original scene or by an optical system that is out of focus. When photographs are produced for remote sensing purposes, blurs are introduced by atmospheric turbulence, aberrations in the optical system and relative motion between camera and ground. In addition to these blurring effects, the recorded image is corrupted by noises too. A noise is introduced in the transmission medium due to a noisy channel, errors during the measurement process and during quantization of the data for digital storage. Each element in the imaging chain such as lenses, film, digitizer, etc. contributes to the degradation. Images are often corrupted with noise during acquisition, transmission, and retrieval from storage media. On loss of reception, random black and white snow-like patterns can be seen on television screens. Noise corrupts both images and videos.

In case of image denoising methods, the characteristics of the degrading system and the noises are assumed to be known beforehand. The image $s(x,y)$ is blurred by a linear operation and noise $n(x,y)$ is added to form the degraded image $w(x,y)$. This is convolved with the restoration procedure $g(x,y)$ to produce the restored image $z(x,y)$.

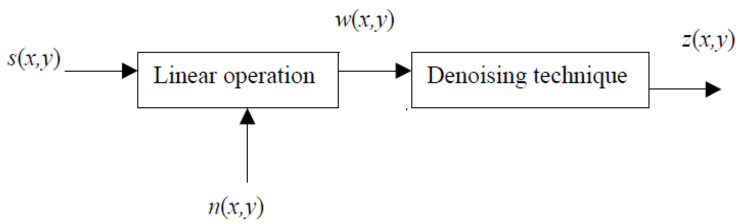

Figure 1.1: Denoising concept.

The "Linear operation" shown in Figure 1.1 is the addition or multiplication of the noise $n(x,y)$ to the signal $s(x,y)$. Once the corrupted image $w(x,y)$ is obtained, it is subjected to the denoising technique to get the denoised image $z(x,y)$.

II. WT (WAVELET TRANSFORM), KLT (KARHUNEN-LOEVE TRANSFORM) AND ADAPTIVE FILTER.

The proposed system is a combination of WT, KLT and adaptive filter. WT is well known for its denoising ability. it is better than other transforms like Fourier transform, Hilbert transform etc.due to following reasons

- It provides the frequency representation of raw signal at any given time interval.
- Wavelet transform can capture the localized feature which is the frequency spectrum of a small time segment
- The computation time which is N for the WT and NlogN for the DFT.
- It has the properties of multiresolution, sparsity and edge detection.

Karhunen-Loeve Transform (KLT) which was built on statistical-based properties. The outstanding advantage of KLT is a good de-correlation. In the MSE (Mean Square Error) sense, it is the best transform, and it has an important position in the data compression technology.

KLT has four characteristics:

- De-correlation: After transform the weight if vector signal Y unrelated.
- Energy concentration: After transform of N-dimensional vector signal, the maximum variance is in the former of M lower sub-vector.
- Under measuring of the MSE: The distortion is less than other transform. It is the sum of the sub-vectors which were omitted.
- No quick algorithm and the different signal sample collection has different transformation matrix. (it is the shortcoming of KLT)

An adaptive filter does a better job of denoising images compared to the other filters. The weight matrix varies after each iteration in the adaptive filter. Adaptive filters are capable of denoising non-stationary images, that is, images that have abrupt changes in intensity. Such filters are known for their ability in automatically tracking an unknown circumstance. In general, an adaptive filter iteratively adjusts its parameters during scanning the image to match the image generating mechanism. This mechanism is more significant in practical images, which tend to be non-stationary.

The adaptive filter is known for its simplicity in computation and implementation. The basic model is a linear combination of a stationary low-pass image and a non-stationary high-pass component through a weighting function. Thus, the function provides a compromise between resolution of genuine features and suppression of noise.

III. ROLE OF WT, KLT AND ADAPTIVE FILTER IN PROPOSED ALGORITHM

WT is well known for its denoising property. Hence, in this algorithm WT is used for denoising the image by using wavelet threshold. Firstly, transform the image into double data vector matrix. And then denoise on the horizon, diagonal, vertical vector. The principle to denoise is that get out the high frequency through controlling the value of the threshold. According to different image, the threshold will not change. Only the data at each point will not be the same while computation. And at last they will give a result of the signal by using integral.

KLT is known for its reconstruction ability. Hence in this system KLT is mainly used to compute the covariance matrix and then use it to rebuild the image after being de-noised using WT. The PCA, in this part, will compute the covariance matrix. The process is to transform a given data set **A** of dimension M to an alternative data set **B** of smaller dimension L, where **B** is the KLT of matrix **A**

An adaptive filter is used to further reduce the noise in the reconstructed image. An adaptive filter does a better job of denoising images compared to the averaging filter. The fundamental difference between the mean filter and the adaptive filter lies in the fact that the weight matrix varies after each iteration in the adaptive filter while it remains constant throughout the iterations in the mean filter.

IV. SIMULATION STEPS

1. Convert the original image into gray image. Because it is hard to indentify the denoise effect in coloured image.
2. Transform the picture into double data vector matrix.
3. The image is affected by the adaptive white Gaussian noise.
4. Use the wavelet functions to denoise the noisy image on the horizon, diagonal and vertical vectors.
5. Reconstruct the image using KLT.
6. Filter the reconstructed image output through adaptive filter.
7. Analyze the PSNR and MSE parameters.

V. SIMULATION RESULTS

The proposed algorithm is verified under two conditions firstly, when SNR=5dB and secondly, when SNR=10dB.

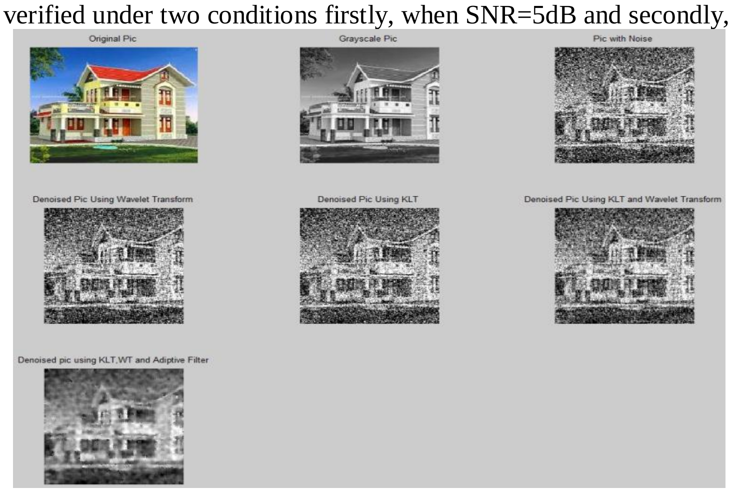

Figure 5.1: Simulation results of proposed algorithm (SNR=5dB).

Figure 5.2: Simulation results of proposed algorithm (SNR=10dB).

The simulation results shows the original image, grayscale image, image with white Gaussian noise, denoised images using wavelet transform alone, KLT alone and with the proposed algorithm.

Table 5.1**:** Analysis of parameters using different algorithms.

S. NO.	SNR	PARAMETERS	WITH WT	WITH KLT	WITH WT and KLT	WITH PROPOSED ALGORITHM
1.	5 dB	PSNR	59.8922	58.8322	60.7472	66.1915
		MSE	0.0667	0.0851	0.0547	0.0156
2.	10 dB	PSNR	64.9041	64.4205	65.7624	67.9233
		MSE	0.0210	0.0851	0.0105	0.0173

The table shows the values of obtained, using different algorithms. From the table analysis it can be concluded that the PSNR and MSE parameters are improved using proposed algorithm in comparison to WT and KLT.

VI. CONCLUSION

In the results PSNR and MSE parameters of proposed system are compares with that of WT alone, KLT alone and combination of WT and KLT systems. It is concluded that the proposed system is better than the other systems under consideration.

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