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BM3D Based On Affine Transformation for Image Denoising

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ABSTRACT

In this paper, BM3D (Block Matching and 3Dimensional) Filtering method is proposed to denoise the image. Wiener filtering and soft thresholding method is used for recovering the original image from the noisy image. The most important technique for removal of noise in images is due to linear motion or unfocussed optics is the Wiener filter. Performance of BM3D method is compared using the parameters such as PSNR (Peak Signal to Noise Ratio) and MSE (Mean Square Error). The performance of BM3D method is analysed with the existing method.
Keywords: Gaussian Noise, Denoising, Wiener Filter, Thresholding.

I. INTRODUCTION

Noise interference and blur occurs during the image acquisition, which degrade the quality of image. The main objective of an image denoising is to remove the noise while reconstruction and not distorting the quality of processed image. Denoising can be done using different methods such as Discrete Wavelet transform (DWT). Vectorial Total Variation (VTV), Non-Local Means algorithm (NLM), Curvelet Transform etc. To denoise an image at the first step, noise is added with the original image. Because an image contains some amount of noise but it is difficult to denoise it. So simulated noise is added to an image. There are different types of noise such as Gaussian noise, White noise, Flicker noise, Salt and Pepper noise, Poisson noise. Usuallly Gaussian noise is added because probability density function is equal to that of the normal distribution. In VTV method clarity of denoising image is not good, PSNR (Peak Signal to Noise Ratio) is low and MSE (Mean Square Error) is high when compared with Non-Local Means algorithm [3]. In this paper Block Matching and 3D Filltering (BM3D) is proposed. Three dimensional affine transformation is used. In affine transformation there are four types translation, scale, shear and rotation.

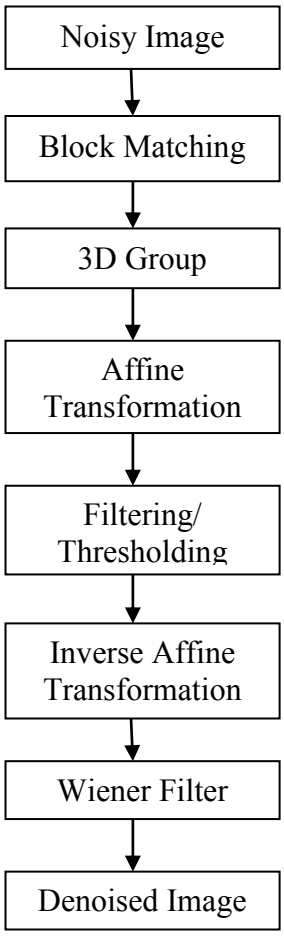

Figure 1. Flow Diagram of BM3D Method

II. METHODS AND MATERIAL

A. Proposed Method

Block Matching and 3D Filtering (BM3D) is the proposed method. In this method wiener filter and soft thresholding are used to denoise the image. In BM3D method, input image is noisy image. Noisy image is

obtained by adding Gaussian noise with the original image. Gaussian noise is added because probability density function is equal to the noise distribution. Probability density function is given by,

$$P(z)=\frac{1}{\sigma\sqrt{2\pi}}e^{\frac{(z-\mu)^2}{2\sigma^2}}$$

In this algorithm noisy image is obtained by adding true image with Gaussian noise. Noisy image is divided into several square blocks. From these blocks, one block is taken as a reference block. Other blocks are compared with the reference block. Then, similar blocks are grouped in a 3D array. Grouping is achieved by block matching.In block matching, distance between reference block and other noisy blocks are calculated by using the following formula.

$$d(Z_{XR},Z_X)=\frac{\left\|\gamma'\left(T_{3D}^{ht}(Z_{XR})\right)-\gamma'\left(T_{3D}^{ht}(Z_X)\right)\right\|^2}{\left(N_1^{ht}\right)^2}$$

$d(Z_{XR},Z_X)-$ Distance between reference and noisy blocks

$\gamma'-$ Threshold operator

$T_{3D}^{ht}(Z_{XR})-$ Normalized 3D linear transform of reference block

$T_{3D}^{ht}(Z_X)-$ Normalized 3D linear transform of noisy blocks

$\|.\|-$ Norm value.

If the distance is less than the threshold value, then which block is consider as a similar block and stored in a 3D array. Then affine transformation is applied for a 3D array. Affine transformation preserves points, straight lines, planes are also used to correct the geometric distortions.

Soft thresholding is applied for the transfsormed image. Thresholding is used to separate the object from its background. In thresholding methods if the image intensity is lessthan threshold then each pixel in an image is replaced by white pixel. If the image intensity is greater than threshold then each pixel in an image is replaced by white pixel. To reduce the noise soft thresholding is applied to the transformed coefficients. Then inverse transformation is applied. After that wiener filtering is applied to reduce the noise. Wiener filter is used to produce the estimate of the desired image. Usually original image contains some unwanted information that is noise which can be eliminated by the wiener filtering. Wiener filtering is used to reduce the mean square error.

B. Parameter Measures

Mean Square Error

Mean Square Error is the difference between reconstructed image and original image.

$$MSE=\frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left[I(i,j)-\hat{I}(i,j)\right]^2$$

Peak Signal to Noise Ratio

PSNR value is calculated to measure the quality of the reconstructed image.

$$PSNR=10\log_{10}\left(\frac{256*256}{MSE}\right)$$

III. RESULTS AND DISCUSSION

The input image is noisy image that is original image is corrupted with Gaussian noise with zero mean and 0.002 variance.

Figure 2. Noisy image

Figure 3. Denoised image

The above Fig 1 shows the noisy image which is the input image. The above Fig 2 shows the denoised image with MSE 0.505 and PSNR 51.12273.

PERFORMANCE ANALYSIS

To analyse the performance of denoising methods the parameters such as Peak Signal to Noise Ratio (PSNR) and Mean Square Error are calculated. Then various denoising methods are compared.

Table 1: Performance Comparision Table

Methods	PSNR	MSE
BM3D	**51.12273**	**0.505**
NLM	29.9991	64.0180
VTV	24.4231	236.6855
Bivariate Pearson Distribution (Hard Thresholding)	21.9997	295.319
Bivariate Pearson Distribution (Soft Thresholding)	21.9162	301.0309

From the performance comparision table concluded that BM3D (Block Matching and 3D Filtering) method has high Peak Signal to Noise Ratio and low Mean Square Error.

IV.CONCLUSION

Various denoising methods involved in the image denoising. But, some methods have low peak signal to noise ratio, uncorrupted pixels also filtered, high mean square error and the image details are not properly recovered. To improve the peak signal to noise ratio and to properly recover the image details, new denoising method is proposed. Thus, image denoising was done for test image using BM3D method and it shows the better result. The performance of denoised image is evaluated using PSNR, MSE.

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