

Image Denoising Using Hybrid Thresholding, MFHT and Hybrid Post Filtering

Taranjot Kaur¹, Manish Mittal²

¹Final Year M. Technology, Computer Science Department, Asra College of Engineering and Technology, Bhawanigarh, India

²Assistant Professor, Computer Science Department, Asra College of Engineering and Technology, Bhawanigarh, India

Abstract: We all know for a fact that various denoising algorithms have already been proposed. However, there is a keen interest of researchers to develop more effective techniques for image denoising. The proposed mechanisms have not been able to attain the desirable results. It is inevitable to stop the noise introduction while acquisition or transmission of the image. The majorly found noise in images is the Gaussian noise. The corruption of image with Gaussian noise is a classical problem till date. This paper can be called an extension to my previous work in which I have proposed a method for the removal of Gaussian noise using a hybrid of Neigh and Bayes thresholding techniques and Discrete Wavelet Transform. Here, we have extended it to more effective modified fast haar transform and applied a hybrid of post filters for better results. The main aim is to minimize the noise as much as possible. The results have been compared on various quality parameters such as PSNR, CNR, Standard Deviation and Entropy.

Keywords: image denoising, Neigh shrink, Bayes shrink, MFHT, Post filtering.

1. Introduction

It is nearly impossible to have an image without the incorporation of noise. All devices have traits that make them susceptible to noise. The unwanted signals mainly called the noise simply degrades the quality of the image and makes it visually unlikable. The major requirement of denoising the image is to retain the quality of image by eliminating the noise and preserving the main features like edges of the image [4][15]. The fact is undeniable that there have been developed various methods regarding this concept. However, it is essential to note that these methods must not alter the details of image. Yet many of the denoising methods corrupt or take away the fine details and texture of the image being processed[7]. It was then, when wavelet transforms emerged during the last decade[12]. There are presently two kinds of wavelet transformations that is continuous and discrete wavelet transform. The Discrete Wavelet Transformation is of utmost consideration over methods like Fourier and Cosine transforms. Wavelets provide a framework for signal decomposition in the form of a sequence of signals[14]. That may be known as approximation signals with decreasing resolution supplemented by a sequence of additional touches called details[10]. The major feature of DWT is to decompose the signal into different frequencies and then analysing them comparing to the resolution according to the scale. The proposed methodology deals with the Gaussian noise only, that is also known as additive white Gaussian noise.

2. Neigh Shrink

The neigh shrink technique for thresholding was proposed by Chen et al. It is a technique that incorporates neighboring coefficients because wavelet transform produces correlated wavelet coefficients[3]. The wavelet is accomplished by applying the low pass and high pass filter on the same set on low frequency coefficients. That means wavelet is correlated in a small neighborhood. A large coefficient will probably have large coefficient at large wavelet coefficient as its

neighbours. The window size variable, it can be 3 X 3, 5 X 5, 7 X 7 etc. However, according to Chen et. al., 3 X 3 is the most appropriate window size[3].

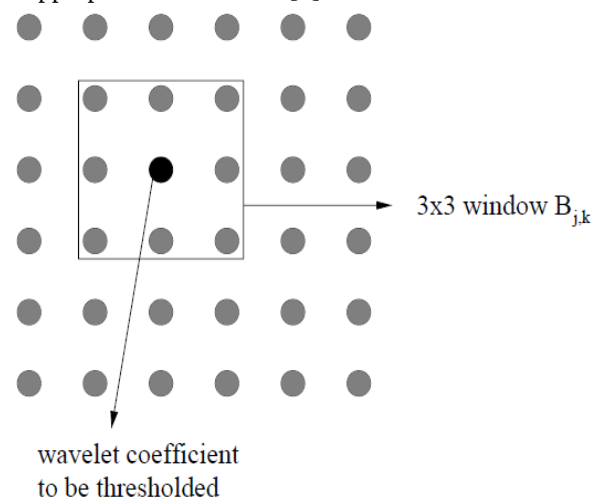


Figure 1: Example of neigh shrink neighbouring window, size 3x3

Let

$$S = \sum_{(i,l) \in B(j,k)} d_{j,k} \quad (1)$$

The corresponding terms are omitted in the summation when it has pixel indices outside the wavelet sub band range. The wavelet coefficient is thresholded according to the following:

$$d_{j,k} = d_{j,k} \beta \quad (2)$$

where the shrinkage factor can be expressed as:

$$\beta = \left(1 - \frac{\lambda^2}{S_{j,k}^2} \right) \quad (3)$$

Here, the + sign indicates to hold the positive value and if its negative, change it to zero.

$$= \sqrt{2\sigma^2 \log} \quad (4)$$

is the universal threshold and is the length of the signal[3].

3. Bayes Shrink

Bayes shrink is considered one of the most proficient method of wavelet thresholding in the field of image denoising[18]. Bayes shrink was proposed by Chang, Yu and Vetterli[4]. It was proposed to minimize the Bayesian risk[21]. It is different from other thresholding techniques as the results come from the Bayesian approach but not from soft or hard thresholding.

$$\sigma_s = \sqrt{\max(\sigma_w^2 - \sigma_s^2, 0)} \quad (5)$$

where σ_s^2 is the variance of the signal[20].

The threshold value proposed in Bayes shrink is a function of noise variance and variance of noiseless data and is independent of the shape parameter[18]. The bayesian rule directly estimates the γ k without using soft or hard thresholding for a specific level[9]. A generalized gaussian distribution for the wavelet coefficients in each sub band is assumed. Then a threshold T is tried to find, that minimizes the Bayesian risk.

4. Modified Fast Haar Transform

These days the non linear methods based on thresholding the Discrete Wavelet Transform (DWT) coefficients have become very popular. The coefficients being generally affected by additive white Gaussian noise[12]. The DWT is basically the decomposition of the signal that provides better spatial and spectral localization[20]. Further, there exist different kind of wavelets for the decomposition in DWT. These can be haar, daubechies, symlets and so on. But nowadays, haar transform is popular among researchers. The haar transform was developed by a Hungarian mathematician named Alfred Haar in 1910[23]. The Haar wavelet is also known as db1. It decomposes each signal into two components, one is called approximation and the other is known as detail[25]. It is known to be the earliest compact and orthonormal wavelet transform[23]. The haar function can be represented as[24]:

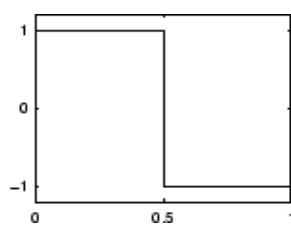


Figure 2: Haar wavelet.

The Haar wavelet uses translations and dilations of the function, i.e. the transform make use of following function:

$$\psi_{a,b}(t) = \frac{1}{\sqrt{a}} \psi\left(\frac{t-b}{a}\right) \quad (6)$$

where a is the scaling parameter and b is the shifting parameter.

Haar transform uses 2^n nodes at n level. By taking average and difference from two nodes from previous level, approximate coefficients and detail coefficients for next level, $n-1$, $n-2$, $n-3$ and so on decomposition nodes are counted, which is known as fast haar transform[24].

In 2007, Chang et. al presented the MFHT technique[24]. The MFHT however takes four nodes at one time rather than two nodes as in case of haar transform and fast haar transform[25]. The values of approximation and detail coefficients are one step ahead of FHT as the intermediate coefficients are ignored. For approximation $(w + x + y + z)/4$ is applied instead of $(x + y)/2$ and for detail, $(w + x - y - z)/4$ is applied instead of $(x - y)/2$. This helps to reduce the unwanted movements of haar coefficients and also reduces the memory requirement[24].

5. Proposed Method

The proposed method is basically a combination of techniques. Firstly, instead of commonly used haar transform, its modified version is being used that is known as modified fast haar wavelet transform (MFHT/MFHWT). The MFHT is used for the decomposition of the image. It is a more efficient method for decomposition as it reduces the computation time and requires less memory for the transformation. Afterwards, the hybridization of the Neigh shrink and Bayes shrink is done for thresholding the wavelet coefficients. The neigh and bayes shrink being two of the most proficient methods for thresholding provide a much more productive result after being hybridized. Furthermore, in the last step, a hybrid of post filters is applied that comprises of adaptive intensity transformations and average (mean) filter. These filters intend to improve the quality of the output image by improving the contrast of the image, improving its texture and smoothening the image. The adaptive intensity transfer function is computed in three decomposed layers using the dominant brightness level, the knee transfer function and the gamma adjustment function. Then, the adaptive transfer function is applied for color preserving and high-quality contrast enhancement. The flow of the work is shown below:

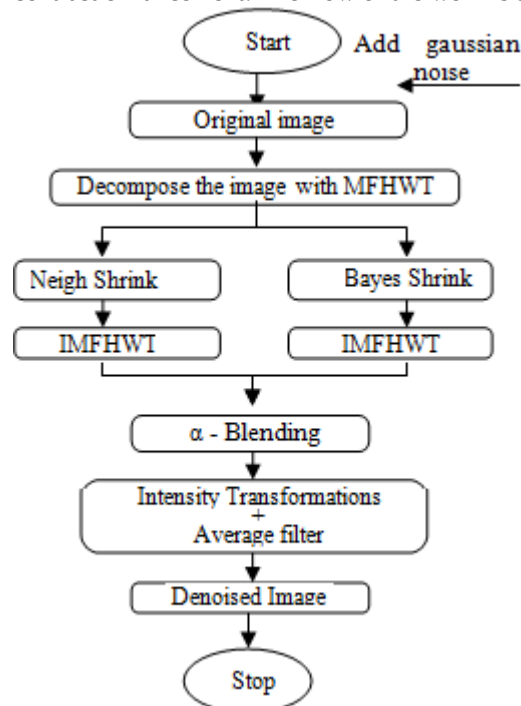


Figure 3: Flow chart for the proposed method

The stepwise functioning of the proposed method is explained below:

- The original grayscale image is first corrupted by Gaussian noise.

- The image is then decomposed. For the decomposition, the modified fast haar transform is used.
- The MFHT reads the image as a matrix. To all the rows and columns, MFHT is applied. From the average and difference of nodes of previous level, the approximate and detail coefficients are counted. The process is called wavelet decomposition and the detail coefficients are called wavelet transform coefficients.
- The decomposed image is then passed through neigh shrink and bayes shrink which convert the image into a set of frequencies by taking a threshold value and changing the values above this threshold to 0. This cleans out the unnecessary details, that are considered as noise.
- For the reconstruction of the image, the inverse of MFHT is considered that is also called wavelet reconstruction. It changes the set of frequencies into a proper image.
- Here, we get two images, one from neigh and another from bayes after reconstruction. So to merge these into a single image, alpha blending is used.
- Further to enhance the quality of image, a hybrid of the intensity transformations and mean filter is used as post filter. Goal is to modify pixel intensity to improve the visibility of objects of interest in the image and smoothen it. And hence, we get the denoised image.

The results are compared on various quality parameters like PSNR, CNR, entropy and standard deviation.

6. Results and Discussions

The proposed method has been executed over different images. Each image is corrupted by gaussian noise. MFHT has led to fast computation of the denoising process. The hybrid of two very good denoising methods i.e. Neigh and Bayes shrink gives better output than the result given by them solely. The post filters being the other highlights provide the image in such a way that it becomes visually more pleasant. The tables below show the results for 3 different test images.

Table 1: Results for test image Boy

Type of method	Quality parameters			
	PSNR	CNR	Entropy	Standard Deviation
Neigh	23.553	57.420	0.388	61.220
Bayes	25.007	39.704	0.354	60.810
Hybrid	27.664	81.549	5.633	65.005

Table 2: Results for test image Charlie Chaplin

Type of method	Quality parameters			
	PSNR	CNR	Entropy	Standard Deviation
Neigh	23.677	74.807	1.096	65.867
Bayes	24.873	54.165	1.032	64.067
Hybrid	30.094	98.457	6.549	69.442

Table 3: Results for test image Dog

Type of method	Quality parameters			
	PSNR	CNR	Entropy	Standard Deviation
Neigh	24.463	87.068	0.148	55.872
Bayes	26.059	59.027	0.142	54.569
Hybrid	29.780	95.751	5.802	59.629



Original image

Noisy image



Neigh Shrink

Bayes Shrink



Hybrid

Figure 4: Example of test image boy when tested with proposed method.



Original image

Noisy image

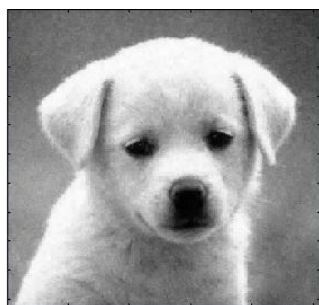
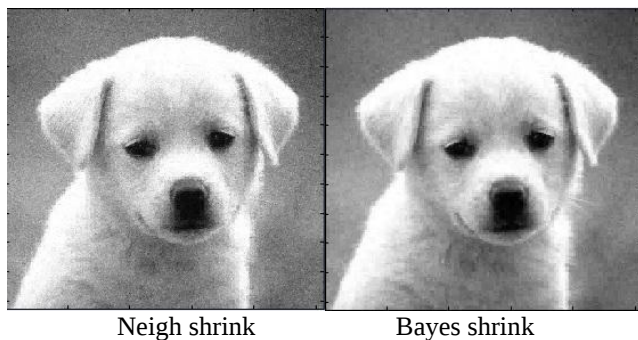
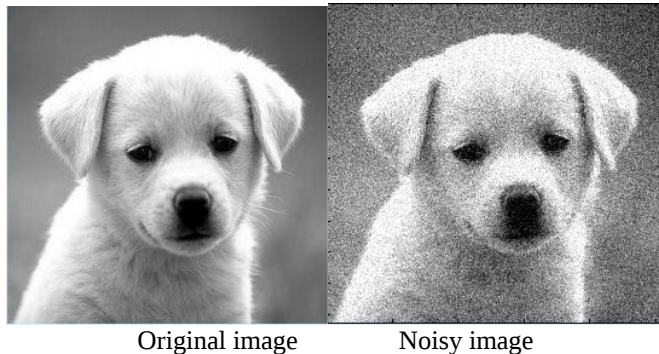


Neigh shrink

Bayes shrink



Hybrid
Figure 5: Example of test image Charlie Chaplin when tested with proposed method



Hybrid
Figure 6: Example of test image Dog when tested with proposed method.

7. Conclusions and Future Scope

In this paper, a new technique has been introduced in order to overcome the image denoising problem. The technique deals with removing the most common gaussian noise. The results clearly prove that the proposed method is way better than the techniques compared to it. The hybridization of the post filters provide an edge to the work.

However, there is no denial to the fact that the study regarding this concept is never ending. In order to get more better results, we can always try for new techniques. In future, we can try to merge some other thresholding techniques with this proposed method to check for better results.

References

- [1] Vikas Gupta, Rajesh Mahle, Raviprakash S. Shriwas. "Image denoising using wavelet transform method" IEEE Tenth International Conference on WOTC (2013).
- [2] David L. Donoho. "De-noising by soft thresholding" IEEE Transactions on Information Theory, Vol. 41, No. 3 (1995)
- [3] G.Y. Chen, T.D. Bui, A. Krzyzak. "Image denoising using neighbouring wavelet coefficients". IEEE International conference on Acoustics, Speech and signal processing, Vol. 2 (2004).
- [4] S. Grace Chang, Bin Yu, Martin Vetterli. "Adaptive wavelet thresholding for image denoising and compression" IEEE transactions of Image Processing Vol. 9, No. 9 (2000).
- [5] A. Buades, B. Coll, J. M. Morel. "A review of image denoising algorithms, with a new one". (2005)
- [6] S. Kother Mohideen, Dr. S. Arumuga Perumal, Dr. M. Mohamed Sathik. "Image Denoising using discrete wavelet transform" IJCSNS Vol. 8, No. 1 (2008).
- [7] A. Buades, B. Coll, J. M. Morel. "A non local algorithm for image denoising" IEEE International Conference on Computer Vision and Pattern Recognition, Vol. 2 (2005).
- [8] Sudipta Roy, Nidul Sinha & Asoke K. Sen. "A new hybrid image denoising method" International Journal of Information Technology and Knowledge Management, Vol. 2, No. 2 (2010).
- [9] Aarti, Gaurav Pushkarna. "Comparative Study of Image Denoising Algorithms in Digital Image Processing" COMPUSOFT, An international journal of advanced computer technology, Vol. 3 (2014).
- [10] Sachin D. Ruikar, Dharmpal D. Doye. "Wavelet based image denoising technique". IJACSA, Vol 2, No. 3 (2011).
- [11] Florian Luisier, Thierry Blu and Michael Unser. "A new SURE approach to image denoising: Interscale orthonormal wavelet thresholding". IEEE transactions on image processing. Vol. 16, No. 3 (2007).
- [12] J. N. Ellinas, T. Mandadelis, A. Tzortzis, L. Aslanoglou. "Image denoising using wavelets".
- [13] Bela Khurana, Ankita Mittal. "Review on image denoising using DWT algorithm". IJSRD Vol. 2 (2014).
- [14] Asem Khmag, Abd Rahman Ramli, Syed Abdul Rahman Al-Haddad, Shaiful Jahari Hashim. "A detailed study of image denoising algorithms using discrete wavelet transformation" IJCST Vol. 5 (2014).
- [15] Li Hongqiao, Wang Shengqian. "A new image denoising method using wavelet transform" IEEE International Conference on IFITA vol 1 (2009).
- [16] Yang Qiang "Image denoising based on haar wavelet" IEEE International Conference on Electronics and Optoelectronics (2011).
- [17] Harnani Hassan , Azilah Saparon "Still image denoising based on discrete wavelet transform" IEEE

International Conference on System Engineering and technology (ICSET) (2011).

- [18] Masoud Hashemi, Soosan Beheshti "Adaptive bayesian denoising for GGD signals in wavelet domain" (2012)
- [19] M. Kociolek, A. Materka, M. Strzelecki, P. Szczypinski. "Discrete wavelet transform- derived features for digital image texture analysis" Proc. of International Conference on signals and electronic systems (2001).
- [20] R. Sihag, R. Sharma, V. Setia. "Wavelet thresholding for image denoising". International Conference on VLSI, Communication and Instrumentation (IJCA) (2011).
- [21] M. Goyal, G.S. Sekhon. "Hybrid threshold technique for speckle noise reduction using wavelets for grey scale images". IJCST Vol. 2, Issue 2 (2011).
- [22] J. Rajan, M.R. Kaimal. "Image denoising using wavelet embedded anisotropic diffusion". IEEE International conference on VIE (2006).
- [23] R.S. Stankovic, B.J. Falkowski. "The haar wavelet transform: Its status and achievements" Computers and electrical engineering 29 (2003).
- [24] Phang Chang, Phang Piau. "Modified fast and exact algorithm for fast haar transform" World academy of science, engineering and technology. Vol 1 (2007).
- [25] A. Bhardwaj, R. Ali. "Image compression using modified fast haar wavelet transform". World applied sciences journal (2009).