# Performance Analysis of Image de-noising using Fuzzy and Wiener Filter in Wavelet Domain

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## ABSTRACT

Images are nowadays, very fundamental type data for transmission. Due to the various components and high speed transmission, images are corrupted by the noises. The Image denoising is required at the receiver end for the faithful communication. There are several methods for image denoising in spatial and transform domain. The current trends of the image denoising research are the evolution of mixed domain methods. In this paper, a mixed domain image denoising method is proposed, which is based on the wavelet transform, median filter and nonlinear diffusion based methods. The wavelet transform is used in this paper to convert the spatial domain image to wavelet domain coefficients. WT produces approximation, horizontal detail, vertical detail and diagonal detail coefficient which represent the various spatial frequency bands. The detail component are removed due to the most of the image part is in approximation part. The approximation coefficient is also filter by fuzzy filters and wiener filter separately. Median and moving average based fuzzy filter are used to apply the filtering on probabilistic way. The trapezoidal membership function are used for the filtering .The peak signal to noise ratio (PSNR) and mean square error (MSE) are used as the performance parameter. The Haar wavelet is used with various filters to optimize the performance of denoising. The combination of Haar wavelet and ATMED filter are giving the best denoising result.

**Key word**: ATMED, ATMEV, MSE, PSNR, Wavelet Transform.

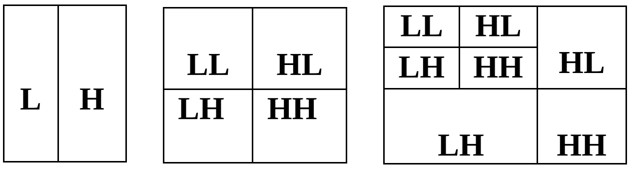
## 1. INTRODUCTION

Denoising image is a method to make an image comprehensible to the human visual system. Digital image are often effect by noise or blurred. Every digital camera imperfection called noise that is nothing but noise which affects the image such as in visual quality and others. Noise may be classified as substitutive noise (impulsive noise: e.g., salt and pepper noise, random valued impulse noise, etc.)[1], additive noise (e.g., additive white Gaussian noise) and multiplicative noise (e.g. speckle noise). Types of image denoising are spatial domain methods and wavelet domain methods [2]. The special filtering is one of the classical linear filtering in spatial domain while the wavelet domain is a new signal estimation method [3]. Wiener Filter for image restoration of blurred image, Wiener Filter shows noise as random process and find estimate of the uncorrupted image such as mean square error between them in minimized e.g. wiener filter can be regarded as a linear estimating method[4]. when apply Wavelet transform on 2D image and work with their detail and approximate coefficient in wavelet domain ,the wavelet domain is used for disintegration of image, but still there is some draw backs for those we are using Fuzzy logic based on triangular member function (e.g. ATMAV, ATMED FILTERS[10]) and performance evaluated on Matlab.

## 2. DENOISING METHODS

### 2.1. Wavelet Transform

The wavelet expansion set is not unique. A wavelet system is a set of building blocks to construct or represent a signal or function. While concerning 2-D image wavelet decomposition the transform can be carried out with a vertical operation to obtain finally four sub image representation [5]. As shown in figure1 two sub images are generate after 2D image decomposition original image into two parts one high frequency coefficient and low frequency. The image HL is the vertical direction high frequency component, LH the horizontal direction high frequency component and LL sub image is the horizontal and vertical direction low frequency component and the HH sub image is the diagonal direction high frequency component. [6].




(a) (b) (c)

**(a) Wavelet transform in column (b) Wavelet transform in row (c) Wavelet transform in both row and column**

**Figure 1: Two dimensional wavelet transform**

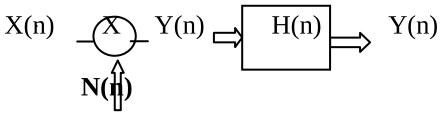
### 2.2. Wiener Filter

The most important technique for removal of blur in images due to linear motion or unfocussed optics is the Wiener Filter [15]. From a signal processing standpoint, blurring due to linear motion in a photograph is the result of poor sampling. Each pixel in a digital representation of the photograph should represent the intensity of a single stationary point in front of the camera. Unfortunately, if the shutter speed is too slow and the camera is in motion, a given pixel will be an amalgam of intensities from points along the line of the camera's motion [7].

The process of extracting the information carrying signal X(n) from the observed signal Y(n).

$$Y(n) = X(n) + N(n)$$

Where: N(n) = noise process



## 2.3. Wiener Filter in the Fourier domain

The Wiener Filter in the Fourier domain is given by the expression [8]

$$F(u,v) = \left[\frac{H*(u,v)}{H(u,v)+\frac{S_n(u,v)}{S_{f(u,v)}}}\right]G(u,v)$$

Where:

H (u,v) is the degraded function

*H** (*u; v*) is the complex conjugate of H (u,v)

*jH*(*u; v*)*j*2 = *H**(*u; v*)*H*(*u; v*)

*S´*(*u; v*) = *jN*(*u; v*)*j*2 is the power spectrum of the noise

*Sf* (*u; v*) = *jF*(*u; v*)*j*2 is the power spectral density (PSD) of the undergirded image

The above expression is based on the following assumptions:

1. The noise and the image are uncorrelated

2. The noise or the image has zero mean

3. The gray levels in the estimate are a linear function of the levels in the degraded image.

The Wiener Filter handles the situation in which the degradation function is zero, unless both the degradation function as well as the noise power spectrum is zero.

## 2.4 .Moving average filter

In the standard moving average filter the value at the central pixel of the window is replaced by the mean value of the corresponding input neighborhood.

### 2.4.1. ATMED

ATMED is the abbreviation for Asymmetrical Triangular Median Filter. In a given neighborhood the filter takes into account the deviation of the pixel value with the median value and replaces the noisy pixel with a fitting output based on fuzzy triangular membership functions [9].The fuzzy filter with triangular function and median value within a window as the center value is given as,

$$O(x,y)= \begin{bmatrix} 1-\left(\frac{I_{med}(x,y)-I(x+i,y+j)}{I_{med}(x,y)-I_{min}(x,y)}\right) \\ \text{for } I_{min}(x,y) \le I(x+i,y+j) \le I_{min}(x,y) \\ 1-\left(\frac{I(x+i,y+j)-I_{med}(x,y)}{I_{max}(x,y)-I_{med}(x,y)}\right) \\ \text{for } I_{med}(x,y) \le I(x+i,y+j) \le I_{max}(x,y) \\ \text{for } I_{max}(x,y)-I_{med}(x,y)=0 \\ \text{or } I_{med}(x,y)-I_{min}(x,y)=0 \end{bmatrix}$$

Where: $I_{max}(x, y)$ , $I_{min}$ (x,y), and $I_{med}$ (x,y) are the maximum value, the minimum value and the median value in the neighborhood [9].

### 2.4.2. ATMAV

ATMAV is the abbreviation for Asymmetrical Triangular Moving Average Filter. In a given neighborhood the filter takes into account the deviation of the pixel value with the mean value and replaces the noisy pixel with a fitting output based on fuzzy triangular membership functions [9]. The fuzzy filter with triangular function and mean value within a window as the center value is given as,

$$O(x,y)= \begin{bmatrix} 1-\left(\frac{I_{med}(x,y)-I(x+i,y+j)}{I_{med}(x,y)-I_{min}(x,y)}\right) \\ \text{for } I_{min}(x,y) \le I(x+i,y+j) \le I_{min}(x,y) \\ 1-\left(\frac{I(x+i,y+j)-I_{med}(x,y)}{I_{max}(x,y)-I_{med}(x,y)}\right) \\ \text{for } I_{mav}(x,y) \le I(x+i,y+j) \le I_{max}(x,y) \\ \text{for } I_{max}(x,y)-I_{mav}(x,y)=0 \\ \text{or } I_{mav}(x,y)-I_{min}(x,y)=0 \end{bmatrix}$$

Where: $I_{max}(x, y)$ , $I_{min}$ (x,y), and $I_{med}$ (x,y) are the maximum value, the minimum value and the median value in the neighborhood.

## 3. METHODOLOGY

- First select an image, check, is it gray image or color image? If color image then firstly convert this image into gray image. Then use it as input image.
- The next step will be to apply wavelet transform (DWT) to decompose the noisy image into four sub images: LL, HL, LH, and HH. After this adopt wiener filter for LL sub image and apply thresholding to remaining sub images.
- After this step we apply fuzzy logic, in the step we used two filters ATMAV & ATMED with haar wavelet.
- Then reconstructs image by wavelet inverse transform, and gets the denoised image.
- Finally, calculate PSNR between original image and noisy image and RMSE between the denoised image and original image.[10]

## 4. RESULTS

The performance for denoising of image were tested on set of grayscale images such as Lena image, (512× 512). Add the Gaussian noise to the image. Perform image denoising via wavelet [13] and wiener filter and fuzzy logic with haar wavelet (ATMAV AND ATMED FILTER)[14]. Table shows the combination different methods (PSNR, RMSE) at different noise level. The ATMED with haar wavelet are giving the best denoising result.

**Table1: PSNR values from different Algorithm**

| Noise | Wiener +wavelet | Haar + ATMAV | ATMAV + Haar | Haar + ATMED |
|---|---|---|---|---|
| 0.01 | 22.59 | 18.94 | 21.44 | 23.54 |
| 0.02 | 21.65 | 18.65 | 20.46 | 22.63 |
| 0.03 | 21.03 | 18.42 | 20.01 | 22.08 |
| 0.04 | 20.59 | 18.19 | 19.34 | 21.46 |
| 0.05 | 20.15 | 18.05 | 18.49 | 20.99 |
| 0.06 | 19.85 | 17.83 | 18.13 | 20.58 |
| 0.07 | 19.46 | 17.64 | 17.75 | 20.15 |
| 0.08 | 19.23 | 17.56 | 17.44 | 19.69 |
| 0.09 | 18.96 | 17.42 | 16.98 | 19.61 |
| 0.1 | 18.76 | 17.25 | 16.63 | 19.29 |

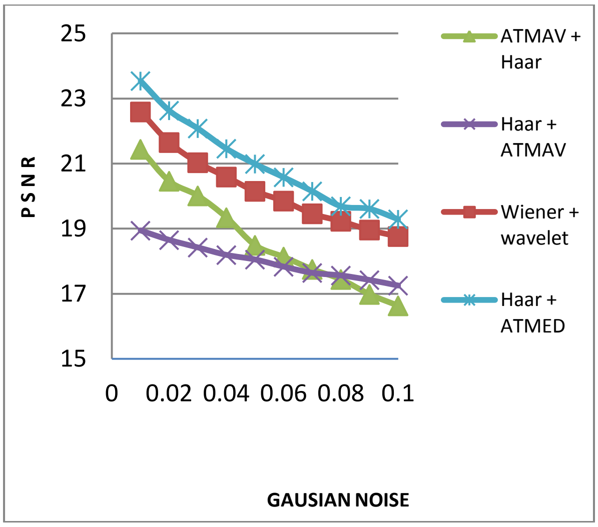



**Figure 2: Graph between NOISE and PSNR**

**Table2: RMSE values from different Algorithm**

| Noise | Wiener +wavelet | Haar + ATMAV | ATMAV +Haar | Haar + ATMED |
|---|---|---|---|---|
| 0.01 | 18.92 | 21.59 | 28.8 | 17.12 |
| 0.02 | 21.02 | 24.17 | 29.78 | 18.83 |
| 0.03 | 22.7 | 25.46 | 30.56 | 20.04 |
| 0.04 | 23.8 | 27.49 | 31.38 | 21.54 |
| 0.05 | 25.05 | 30.33 | 31.89 | 22.76 |
| 0.06 | 25.93 | 31.6 | 32.73 | 23.84 |
| 0.07 | 27.1 | 33.01 | 33.43 | 25.04 |
| 0.08 | 27.83 | 34.23 | 33.75 | 26.39 |
| 0.09 | 28.74 | 37.09 | 34.29 | 26.66 |
| 0.1 | 29.4 | 37.57 | 34.98 | 27.65 |

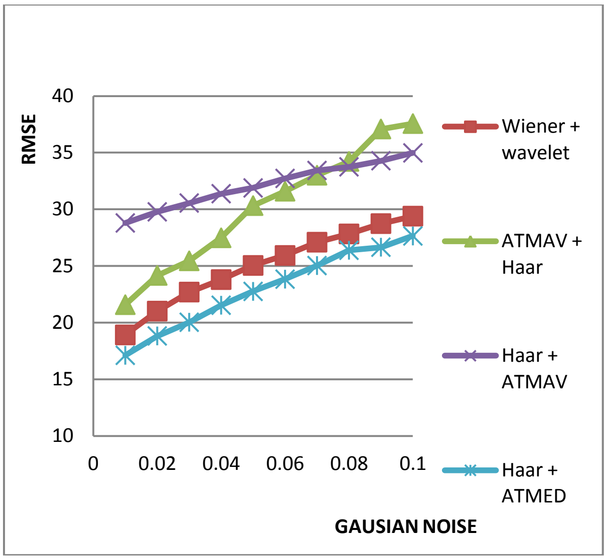



**Figure 3: Graph between NOISE and RMSE**


**Fig 4: (a)** **Fig 4: (b)**


**Fig 4: (c)** **Fig 4: (d)**


**Fig 4: (e)** **Fig 4: (f)**

**Figure 4: Resulting images from different algorithm**

**(a) Original image (b) Noisy image (c) Wiener and Wavelet (d) Haar and ATMAV (e) ATMAV and Haar (f) Haar and ATMED**

## 5. CONCLUSION

In this thesis image denoising using combination of techniques has been discussed. In the first part of thesis we introduced wavelet transform and wiener filter for image denoising. In the later part of paper, proposed two different techniques for image denoising. The first technique is fuzzy logic based filter i.e. ATMAV filter with Haar wavelet transform and 2nd technique for image denoising i.e. is also based on fuzzy logic filter ATMED with Haar wavelet transform. After all this techniques results are carried out in two terms peak signal to noise ratio (PSNR) and mean square error (MSE).while comparative analysis of all techniques and Based on the result, we conclude that

- The ATMAV with haar gives worst result for image denoising.
- The ATMED with haar wavelet gives good result as compared to wiener filter.
- Thus we conclude that ATMED with haar wavelet is better technique for image denoising.

# 6. FUTURE WORK

Since selection of the right denoising procedure plays a major role, it is important to experiment and compare the methods. As future research, we would like to work further on the comparison of the denoising techniques.

- It may introduce Adaptive fuzzy logic which gives better result.
- We can apply multiple wavelet transform with present technique.

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