

Decimated and Undecimated Wavelet Transforms Based Estimation of Images

Koteswararao M¹, Dr. V.V.K.D.V. Prasad²

M.Tech Student, Gudlavalleru Engineering College, Krishna, Andhra Pradesh, India¹

Professor of ECE, Gudlavalleru Engineering College, Krishna, Andhra Pradesh, India²

ABSTRACT: Estimating the images using wavelet transform is very popular method in different applications. In this paper a new thresholding function is developed with the combination of SCAD function and Soft function, it is introduced for wavelet based estimation of images. The performance of this function is tested by decimated and undecimated wavelet transforms. The qualities of image denoising are tested by the root mean square error (RMSE) and peak signal to noise ratio (PSNR). The performance of the new thresholding function gives better results than compared to decimated and undecimated wavelet transforms.

KEYWORDS: Wavelet transform, image denoising, decimated wavelet transform, undecimated wavelet transform, new thresholding function

I. INTRODUCTION

In many applications images are used. They will be transmitted from one place to another place, in this process some noise will be added to the images. Image denoising is used to produce good estimates of the original image from noisy observation. In image denoising so many methods like Gaussian filter, Non local mean, DUDE, Bilateral, Wiener filter, and Wavelet transform etc, .Out of this method mostly used technique for image denoising is wavelet transform. In this wavelet transform, the shrinkage method is popular method for estimation of images.

II. ALGORITHM FOR IMAGE DENOISING

In the field of image processing major problem occurred with noisy image. Estimation of images used to produce the good estimator for the original image from noisy image. The algorithm for the image denoising involves the following steps

- a. The wavelet transform is applied on the noisy image
- b. The output of the wavelet transform is noisy image wavelet coefficients
- c. Then the threshold value is fixed by applying the threshold rule
- d. The wavelet coefficients are changed using the threshold function
- e. The output of this function is applied to the inverse wavelet transform
- f. It gives the de-noised image or original image

The above algorithm for image denoising is implemented with different noise levels, different images and different wavelets. These results are compared across the different methods.

III. DECIMATED AND UNDECIMATED WAVELET TRANSFORM

Decimated Wavelet Transform: If the number n of the wavelet coefficients p is depending on the type of the wavelet transform (decimated or undecimated) are used. The wavelet transform consist of both wavelet coefficient and scaling coefficients. The number of data points same as the number of coefficients in p in the decimated wavelet transform

Top Method: This method is not depending on thresholding filter. In this the threshold value is calculated from data, so standard deviation is not required. If k is the largest detailed coefficient to keep, then the threshold value is $(1-k)$ th quintile of empirical distribution of absolute values of detailed coefficients.

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Universal Method: This method was developed by Donoho and Johnstone. This is a universal thresholding method not depending on thresholding filter selected. The threshold value is calculated by

$$\lambda = \sigma \sqrt{2 \log l}$$

Where σ is the standard deviation, l is the length of the signal and λ is the threshold value

Undecimated wavelet transform: Undecimated means there is no decimation. Undecimated wavelet transform is applied on both down sampling in the forward wavelet transform and up-sampling in the inverse wavelet transform process.

Translation Invariant Method: Donoho and Coifman are introduced the translation invariant rule, it consists of carrying out shrinkage on each basis and taking the average of the obtained de-noised signals. There are two challenging effects present a improved detection of singularities due to taking into account all the shifts in the analysis and an effect of more powerful smoothing due to the averaging of the de-noised signals on each basis. A good cooperation consists of using quite unbalanced wavelet with a small support and applying soft shrinkage. This method can get better the compensation of the edges and it is also used for estimation of images.

IV. SHRINKAGE FUNCTION

Threshold rules are applied on the data and simply determine the shrinkage function. There are different categories of shrinkage functions

Soft Shrinkage Function: If the coefficient value (p) is greater than the threshold value (λ), then it taken as the difference between coefficient value and threshold value otherwise the value is zero.

$$S(p, \lambda) = \begin{cases} \text{sgn}(p)(|p| - |\lambda|) & \text{for } |p| > \lambda \\ 0 & \text{otherwise} \end{cases}$$

Algorithm for soft shrinkage function

- The coefficient values are taken as input to this function.
- If the coefficient value is greater than the threshold value, then it taken as the difference between coefficient value and threshold value
- If the coefficient value is less than the threshold value, then it taken as the zero value

SCAD Function:

$$SCAD(p, \lambda) = \begin{cases} \text{sign}(p) \max(0, |p| - \lambda) & \text{if } |p| \leq 2\lambda \\ (\alpha - 1)p - \alpha \lambda \text{ sign}(p) & \text{if } 2\lambda \leq |p| < \alpha\lambda \\ p & \text{if } |p| > \alpha\lambda \end{cases}$$

Where $\alpha=3.7$, SCAD means smoothly clipped absolute deviation

New Thresholding Function:

Algorithm for new thresholding function

- New thresholding function is newly designed filter in this project.
- It is developed based on the arithmetic mean of the SCAD function and soft thresholding function.
- If the coefficient value (p) is greater than the thresholding value (λ), then it allows the function value, otherwise it's taken the twenty percentage of coefficient value with output of function.

V. RESULTS AND DISCUSSION

The performance of the proposed thresholding function is evaluated and compared with, soft and SCAD thresholding functions using wavelets. The experiment is conducted on the image 512 X 512 of size. The Gaussian noise with different variations added to the input image. By applying the wavelets transforms to get the wavelet coefficients those

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coefficients are modified according in to the thresholding function and apply the inverse wavelet transforms on the image finally get the original image or denoising image. The performance of the denoising is evaluated by using the PSNR & RMSE.

RMSE is defined as root mean squared error between original image and denoising image

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (X(i) - \hat{X}(i))^2}$$

$$PSNR = 20 \log_{10} (255/\sqrt{MSE})$$

Where $X(i)$ the original image is $\hat{X}(i)$ is the de-noised image, n is number of samples. The simulation experiment is repeated 100 times and average values are taken the process is conducted on different images and the results are same. This simulation is developed in MATLAB environment. The results of images for $\sigma=10, 20$ and 30 using Soft, SCAD and new thresholding filter with translation invariant method and top rule method are shown in Table 1 and Table2. Table 3 indicates the denoising results using universal method. The original and de-noised images using new thresholding filter with translation invariant method and Top rule method are shown in Figs a-d. Fig e shows de-noised image using universal method. Graph 1-6 show the comparison of the results of translation invariant, top rule and universal methods.

For $\sigma=10$, RMSE is 9.9789 and PSNR is 28.1491 are obtained on denoising of noisy image with SCAD filter and RMSE is 12.5291 and PSNR is 26.1724 are obtained with soft thresholding function using translation invariant method (Table1). For new thresholding function RMSE of 8.0126 and PSNR of 30.0554 are obtained (Table 1). From the above values, we can observe the new thresholding function performs better than the SCAD and soft thresholding function. Similarly performance is obtained for the remaining values $\sigma=20$ and 30 (Table 1).

Using Top Rule method, for $\sigma =10$, RMSE of 8.6680 and PSNR of 29.3725 are obtained on denoising of noisy image with SCAD thresholding filter and RMSE of 7.7700 and PSNR of 30.3224 are obtained with soft thresholding filter and RMSE of 8.6898 and PSNR of 29.3506 are obtained with new thresholding function similarly for $\sigma=20, 30$ are calculated (Table 2).). From the above values, we can observe the new thresholding function performs better than the Soft function.

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Using Universal method, for $\sigma =10$, RMSE of 9.5243 and PSNR of 28.5541 are obtained on denoising of noisy image with SCAD thresholding filter and RMSE of 13.6533 and PSNR of 25.4261 are obtained with soft thresholding filter and RMSE of 9.6893 and PSNR of 28.4049 are obtained with new thresholding function similarly for $\sigma=20, 30$ are calculated (Table 3). From the above values, the new thresholding function performs better than the SCAD function.

Table 1: Denoising results of Canaletto image in Translation invariant method

	$\sigma =10$		$\sigma =20$		$\sigma =30$	
	RMSE	PSNR	RMSE	PSNR	RMSE	PSNR
Noisy image	9.9616	28.1642	19.9724	22.1222	29.9724	18.5964
Estimation using SCAD function	7.2515	30.9223	11.0058	27.2984	12.0765	26.4920
Estimation using Soft function	9.2539	28.8043	12.8294	25.9667	16.3175	23.8777
Estimation using new thresholding function	5.8235	32.8271	8.3848	29.6610	10.9341	27.3552

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Table 2: Denoising results of Canaletto image in Top method

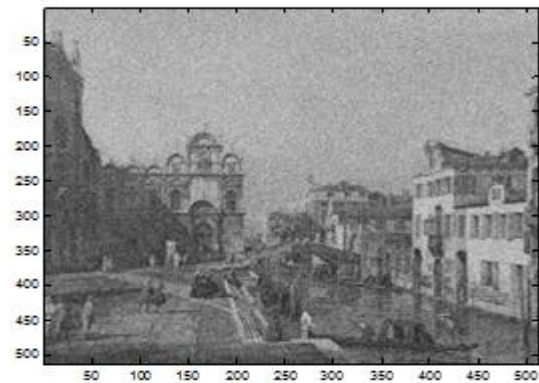
	$\sigma=10$		$\sigma=20$		$\sigma=30$	
	RMSE	PSNR	RMSE	PSNR	RMSE	PSNR
Noisy image	9.9878	28.1414	20.0409	22.0925	30.0266	18.5807
Estimation using SCAD function	6.2210	32.2536	9.8409	28.2701	15.4798	24.3355
Estimation using Soft function	6.1387	32.3693	8.7308	29.3097	11.6943	26.7713
Estimation using Novel shrinkage function	5.4591	33.3884	8.6704	29.3700	12.9522	25.8839

Table 3: Denoising results of Canaletto image in Universal method

	$\sigma=10$		$\sigma=20$		$\sigma=30$	
	RMSE	PSNR	RMSE	PSNR	RMSE	PSNR
Noisy image	10.016	28.1164	19.9513	22.1314	30.0607	18.5708
Estimation using SCAD function	7.0898	31.1182	10.6929	27.5489	12.6138	26.1139
Estimation using Soft function	9.6385	28.4506	14.3158	25.0145	15.7574	24.1811
Estimation using Novel shrinkage function	6.9282	31.3184	10.1255	28.0225	13.0688	25.8061



a



b



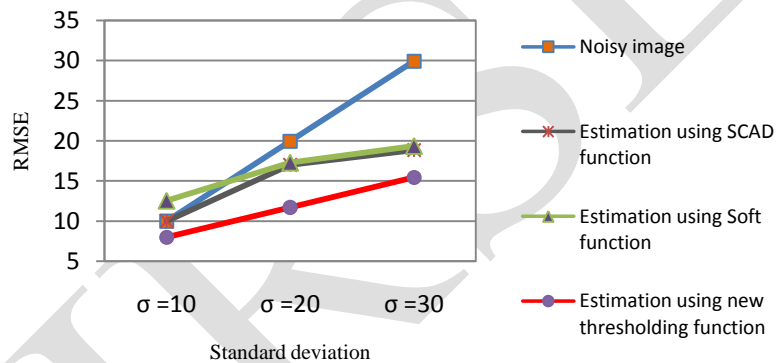
c



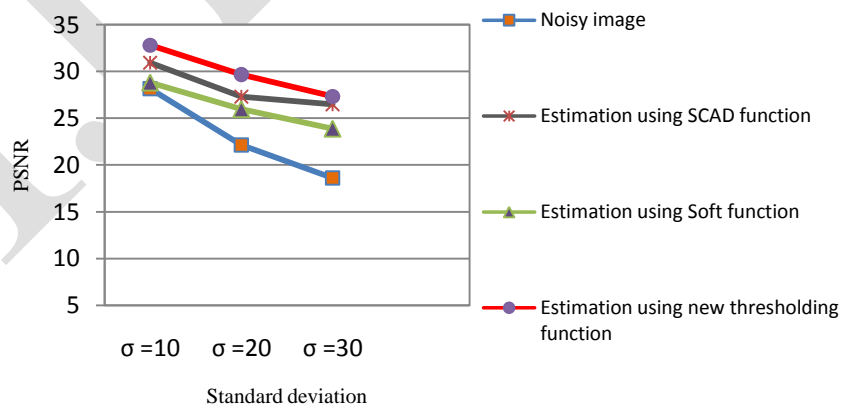
d



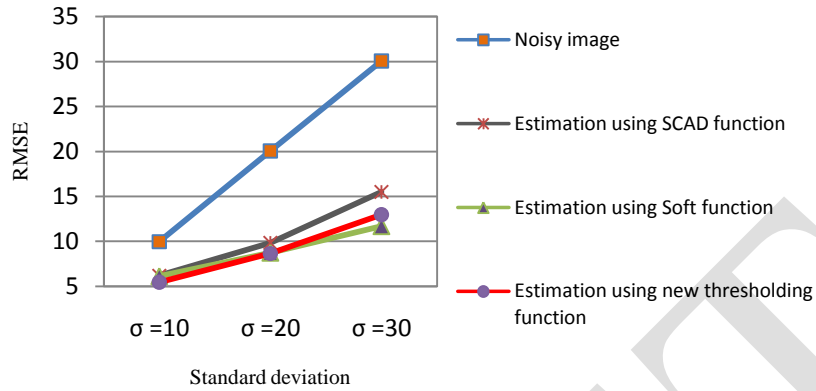
Fig. 1 Image denoising (a) Original image (b) noisy image($\sigma=30$) (c) de-noised image using new thresholding function with Translation invariant method (d) de-noised image using new thresholding function with Top method (e) de-noised image using new thresholding function with Universal method



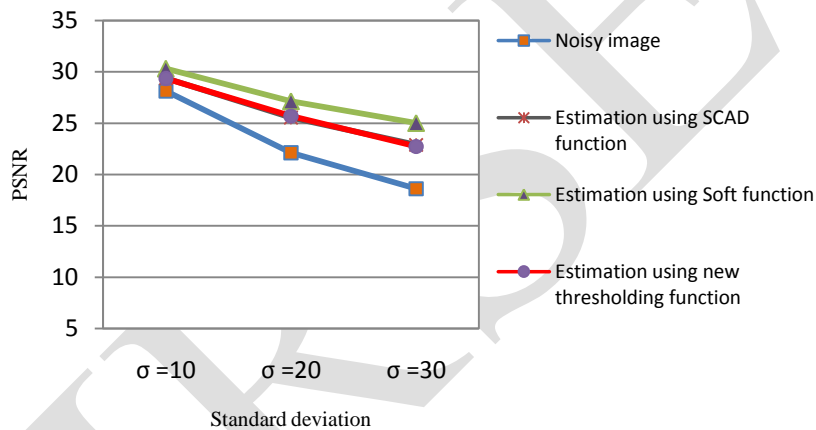
Graph 1: RMSE values of different functions in Translation invariant method



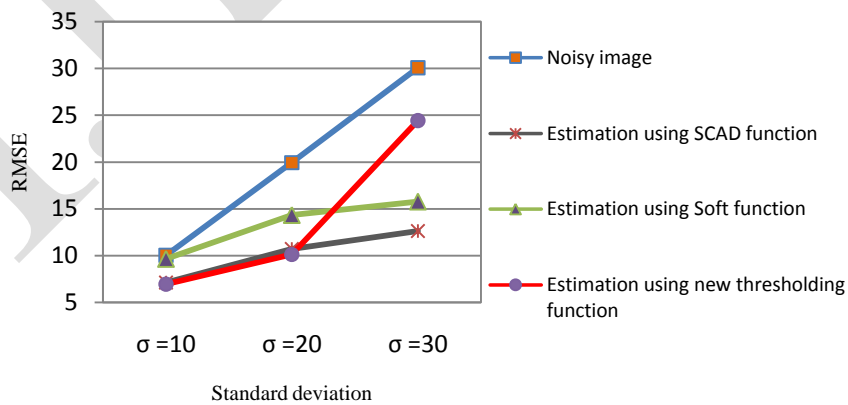
Graph 2: PSNR values of different functions in Translation invariant method



Graph 3: RMSE values of different functions in Top method



Graph 4: PSNR values of different functions in Top method

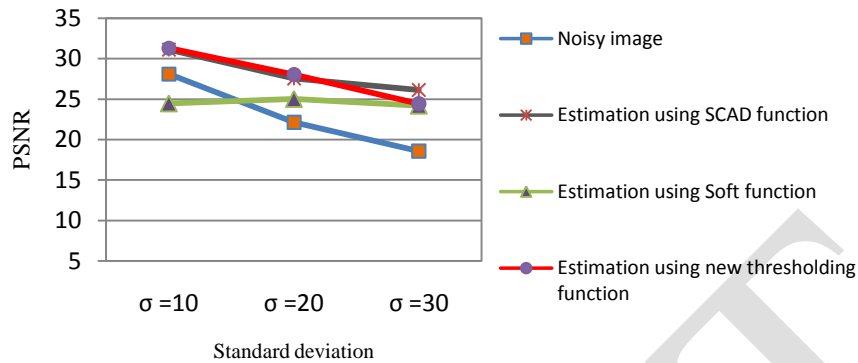


Graph 5: RMSE values of different functions in Universal method

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Graph 6: PSNR values of different functions in Universal method

VI. CONCLUSION

In this paper, new thresholding function for wavelet thresholding denoising of image is proposed. The performance of this filter is evaluated for Canaletto image using decimated and undecimated wavelet transforms. These results are compared with existing soft and SCAD functions. In the undecimated wavelet transform the new thresholding function performs better results than compare to SCAD and soft function. In decimated wavelet transform, the new thresholding function gives better results than compared to soft function in Top method and new thresholding function gives better results than compared to SCAD function in Universal method.

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BIOGRAPHY



KOTESWARARAO M received the B.Tech degree in Electronics and Communication Engineering in 2011 from Nalanda institute of engineering & technology, M.Tech pursuing Digital Electronics and Communication Systems in Gudlavalleru engineering college.



Dr.V.V.K.D.V. PRASAD presently working Professor of ECE in Gudlavalleru engineering college. Current area of research in denoising of signals and images using wavelet transforms and S transforms.

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