Wavelet Multiscale Denoising

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Abstract— **Image denoising is one very important thing when we talk about image processing, the goal of which is to separate the noise from the image as best as possible. A number of methods have been presented to deal with this practical problem over the past several years. The best currently available wavelet-based denoising methods take advantage of the merits of the wavelet transform. Most of these methods, however, still have difficulties in defining the threshold parameter which can limit their capability.**

I. Introduction

As we said, image denoising as a low-level image processing operator is an important front-end procedure for high-level visual tasks such as object recognition, digital entertainment, and remote sensing imaging. Noise is a random variation of image intensity and appears as grains in the image. It may arise in the image as effects of basic physics-like photon nature of light or thermal energy of heat inside the image sensors. Noise means that the pixels in the image show different intensity values instead of true pixel values. Digital images may be contaminated during acquisition, transmission, and compression, by diverse types of noise, generated by different causes, such as signal instabilities, defective sensors, physical deterioration of the materiel due to aging, poor lighting conditions, errors in the transmission due to channel noise, or interference caused by electromagnetic fields. Noise suppression is of great interest in digital image processing, considering that the quality improvement of corrupted images is of essential importance for the majority of image processing areas, including analysis of images, detection of edges, and pattern recognition.

II. Wavelet transform

In this paper we are going to research the ways and methods of wavelet transform noise removal. Its one of the fastest and most effective noise removal. First, what is a wavelet anyway? The wavelet was created to replace the Fourier function, which had a disadvantage in compiling information about spatial frequency. wavelet covered the shortcomings of Fourier, and proved to be a useful solution for image denoising. We can se on Image 1. To achieve this goal, wavelet uses threshold techniques such as soft and hard threshold. The process of denoising. Denoising is accomplished by transforming back the processed wavelet coefficients into spatial domain. The small threshold retains the noise coefficients, so that after application the image may be noisy, in contrast to the hard threshold, which will still make the image a little smoother, so today we will check which method is still the best in our case if we use histology images.

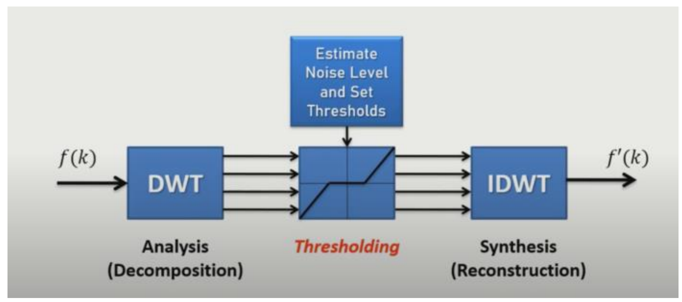

Image 1. Wavelet denoising process

III. Wavelet thresholding

The idea of thresholding was motivated created by the following assumptions made by and listed below:

- Noise is spread out equally along all coefficients.
- The de correlating property of a wavelet transform creates a sparse signal most untouched coefficient is zero or close to zero.
- The noise level is not too high so that the signal wavelet coefficients can be distinguished from the noisy ones. This process is well known as a simple and effective for noise decrease. Further, inserting zeros creates more scarcity in the wavelet domain.

For soft thresholding we can also say shrinkage function because it takes the argument and shrinks the coefficient towards zero by the threshold U Thresholding operator is defined by equation.

$$D(U,I) = sgn(u)max(0, |u| - I)$$

Hard thresholding operator is defined by equation

$$\mathrm{D(U,I)} = \begin{Bmatrix} U & for \quad all\ |U| > \lambda \\ 0 & otherwise \end{Bmatrix}$$

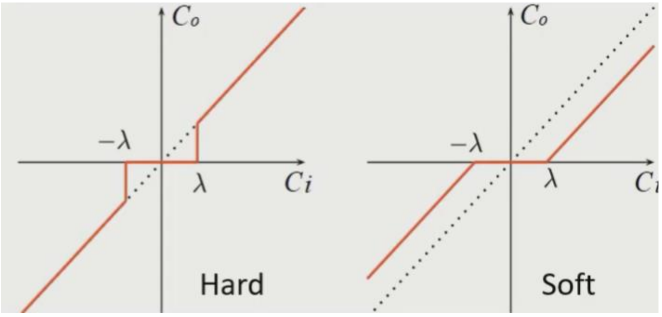

Image 2. Hard and Soft thresholding

IV. HAAR WAVELET

Haar wavelet is also called ‘mother wavelet’ and it is the first and simplest form of wavelet. Haar wavelet is a sequence of rescaled "square-shaped" functions which together form a wavelet family or basis. We can defind it by equation

$$\psi(t) = \begin{cases} 1 & 0 \leq t < \frac{1}{2}, \\ -1 & \frac{1}{2} \leq t < 1, \\ 0 & \text{otherwise.} \end{cases}$$

And its scaling function can be described as this

$$\varphi(t) = \begin{cases} 1 & 0 \leq t < 1, \\ 0 & \text{otherwise.} \end{cases}$$

We will explain you a simple example about how Haar wavelet works. In this case we have a 1D array of 4 pixels (Table 1.) and we need to calculate the pixel average as a first step. So we use the middle number for every two numbers in the group and store their difference. we repeat this process until we reach the last number.

Resolution	Averages	Detail Coefficients
4	[9 7 3 5]	
2	[8 4]	[1 -1]
1	[6]	[2]

Table 1.

So, the wavelet transform of the original four-pixel image is given by [6 2 1 - 1], for the 1D Haar basis. The image can be reconstructed to any resolution by recursively adding and subtracting the detail coefficients from the lower resolution versions.

V. PSNR

PSNR (Peek signal noise ratio) is a measure to define similarity and noise between original image and certain image. It is commonly used to quantify reconstruction quality for images and video subject to lossy compression. So, we will use it to measure our results. As you can se on image 3. I was ploting (in order) original image, image with noise, bayes denoised noisy image and visus denoised noisy image. Right now it doesn't matter which methods we used. Important thing is that, when we use PSNR method we have to sompare our imageswith original image always. So we can see that our PSRN result for noisy image is around 13,7, and for denoised images is around 20-21. That says that, the higher the PSRN is, the more similar our image is to the original.

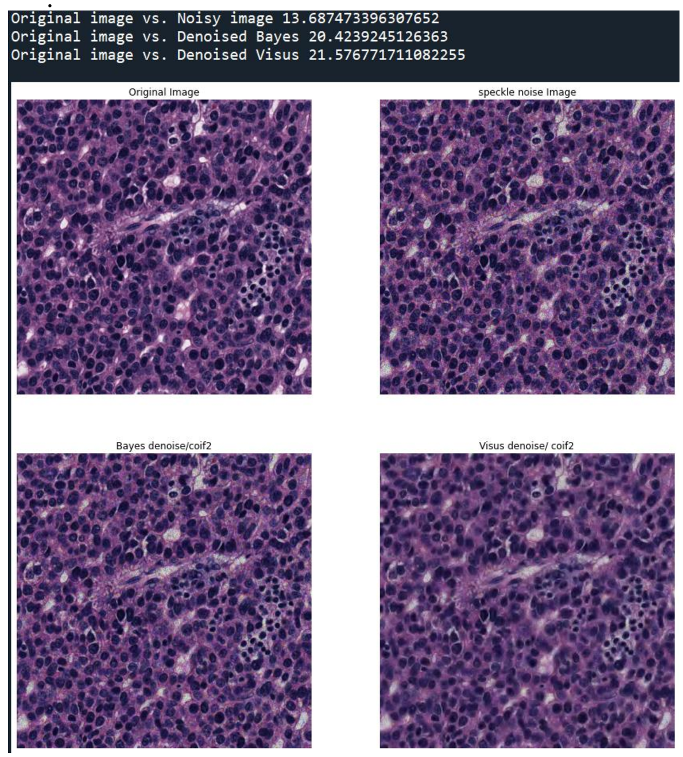

Image 3. Applying PSNR

VI. RESULTS

For our research and finding the best de-noise methods, we used both Bayes and Visis shink denoise methods, as well as both hard and soft threshold methods. From the wavelet functions we used Haar, Symlet, Coiflets and Daubechies and on them we tried wavelet levels from 1-4.

Denoise method	mode	wavelet	Wavelet levels	PSN
Bayes Shrink	soft	coif2	4	25.282067
Bayes Shrink	soft	coif2	3	24.986305
Bayes Shrink	soft	db2	4	24.858368
Bayes Shrink	soft	sym2	4	24.858368
Bayes Shrink	soft	sym2	3	24.585403
Bayes Shrink	soft	db2	3	24.585403
Bayes Shrink	soft	haar	4	23.879114
Bayes Shrink	hard	coif2	4	23.870839
Bayes Shrink	hard	coif2	3	23.776718
Bayes Shrink	soft	haar	3	23.656424

Picture 5. Denoising test results

We can notice that the Bayes shrinking method is the absolute winner over the Visas method, as well as soft thresholding, in our case over histology images. Also, the Coiflet wavelet function gives us the best results.

VII. Conclusion

The wavelet denoise method is a really fast and simple method to denoise an image, but I definitely think there is still room for improvement, as well as simplifying the selection of the denoising method.

References

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