

Biomedical Image Denoising and Compression in Wavelet using MATLAB

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Abstract— Biomedical image processing is similar in concept to biomedical signal processing in multiple dimensions. Medical Images normally have a problem of high level components of noises. Image denoising is an important task in image processing, use of wavelet transform improves the quality of an image and reduces noise level. A novel theory is introduced for analyzing image compression methods that are based on compression of wavelet decompositions. This theory precisely relates (a) the rate of decay in the error between the original image and the compressed image as the size of the compressed image representation increases (i.e., as the amount of compression decreases) to, (b) the smoothness of the image in certain smoothness classes called Besov spaces. Within this theory, the error incurred by the quantization of wavelet transform coefficients is explained. Based on previous experimental research it is argued that in most instances the error incurred in image compression should be measured in the integral sense instead of the mean-square sense. Here a biomedical image has been taken for de-noising and compression in Wavelet Toolbox specially Wavelet 2D in MATLAB and MATLAB command prompt using step by step. As a result we get the compressed image as well as noise free in vertical, horizontal and diagonal details and got energy ratio.

Index Terms— Wavelets, Image Processing, Medical Image, Image De-noising, Image Compression.

I. INTRODUCTION

Image processing field is a huge one. It encompasses in the following areas: 1. Image Compression; 2. Image De-noising; 3. Image Enhancement; 4. Image Recognition; 5. Feature Detection, 6. Texture Classification. Wavelet-based techniques apply to all of these topics. Reason is wavelet analysis provides such an all-encompassing tool for image processing for a similar type of analysis occurs in the human visual system. To be more precise, the human visual system performs hierarchical edge detection at multiple levels of resolution and wavelet transforms perform a similar analysis. Compression is the process of reducing large data files into smaller files for efficiency of storage and transmission. Data compression techniques are: a. Lossless data compression, b. Lossy data compression. Lossless data compression is nothing but the original data can be reconstructed exactly from compressed data. Lossy data compression in which data after compression and then decompression retrieves a file that is not exactly as the original data as there will be loss of data. De-noising plays a very important role in the field of the medical image pre-processing.

It is often done before the image data is to be analyzed. Denoising is mainly used to remove the noise that is present and retains the significant information, regardless of the frequency contents of the signal. It is entirely different content

and retains low frequency content. De-noising has to be performed to recover the useful information. In this process much attention is kept on, how well the edges are preserved and how much of the noise granularity has been removed [8-9]. The main purpose of an image-denoising algorithm is to eliminate the unwanted noise level while preserving the important features of an image. In wavelet domain, the noise is uniformly spread throughout the coefficients while mostly the image information is concentrated in the few largest coefficients.

II. WAVELET TRANSFORM

In most of the applications of image processing, it is essential to analyze a digital signal. If the data will be transformed into any other domain then the structure and features of the signal may be better understood. There are several transforms available like Fourier transform, Hilbert transform, Wavelet transform, etc. The wavelet transform is better than Fourier transform because it gives frequency representation of raw signal at any given interval of time, but Fourier transform gives only the frequency- amplitude representation of the raw signal but the time information is lost. So we cannot use the Fourier transform where we need time as well as frequency information at the same time. Wavelets are mathematical functions that cut up data into different frequency components. The fundamental idea behind wavelets is to analyze the signal at different scales or resolutions, which is called multiresolution. The most important feature of wavelet transform is it allows multiresolution decomposition.

III. IMAGE DENOISING

An image is often corrupted by noise in its acquisition and transmission. Image de-noising is used to remove the additive noise while retaining as much as possible the important signal features. In the recent years there has been a fair amount of research on wavelet thresholding and threshold selection for signal de-noising [1], [3],[8],[10], because wavelet provides an appropriate basis for separating noisy signal from the image signal. The motivation is that as the wavelet transform is good at energy compaction, the small coefficients are more likely due to noise and large coefficient due to important signal features [12]. These small coefficients can be thresholded without affecting the significant features of the image.

IV. BASIC MODEL OF COMPRESSION SYSTEM

Most of the compression systems are based upon reducing the redundant information present in the signal whether it is 1D signal or 2D signal like image. Sometime redundancy reduction process is performed over the transformed signal rather than the original signal itself.

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The redundancy depends upon the entropy of the signal. Redundancy reduction removes highly correlated data which is more in case of image due to much of the low frequency content in it. Discrete Wavelet Transform (DWT) [7] has emerged as a popular technique for redundancy reduction. DWT has high de-correlation and energy compaction efficiency. Non-significant information is removed from the data by this process but it is a non-reversible process electronically for review. The popular entropy coding techniques are Huffman coding and Arithmetic coding which are used many times in compressing data and also in image compression techniques. An image that is decomposed by wavelet transform can be reconstructed with desired resolution. The most important feature of wavelet transform is it allows multiresolution decomposition. The procedure for this is a low pass filter and a high pass filter is chosen, such that they exactly halve the frequency range between themselves. This filter pair is called the Analysis Filter pair. First of all, the low pass filter is applied for each row of data, and then we obtain low frequency components of the row. As the LPF is a half band filter, the output data consists of frequencies only in the first half of the original frequency range. By Shannon's Sampling Theorem, they can be sub sampled by two, so that the output data contains only half the original number of samples, similarly the high pass filter is applied for the same row of data, and now the high pass components are separated, and placed by the side of the low pass components. This procedure is done for all rows.

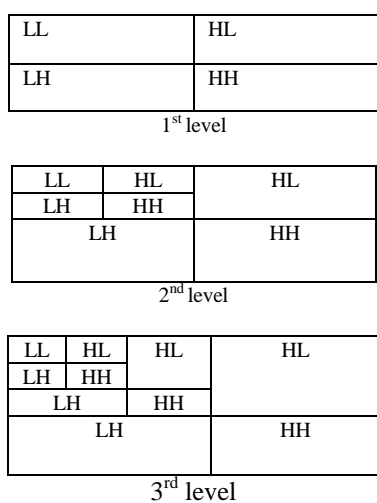


Fig 1 – wavelet decomposition

Next, the filtering is done on each column. as a result we get four bands of data, each labeled as LL (low-low), HL (high-low), LH (low-high) and HH (high-high).The LL band can be decomposed once again in the same manner, thereby producing even more sub bands[8]. This can be done up to any level, thereby resulting in a pyramidal decomposition as shown above the LL band at the highest level can be said as most important, and the other bands are of lesser importance, the degree of importance decreases from the top of the pyramid to bottom.

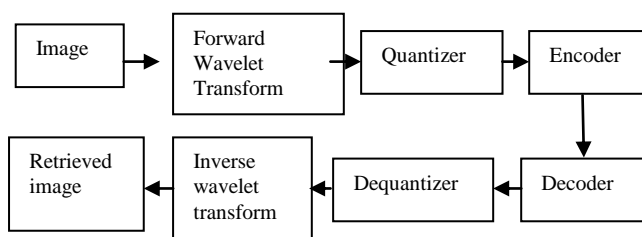


Fig -2: Block diagram for image compression

V. DENOISING IN WAVELET 2D

For generating MATLAB code to reproduce GUI-based 2-D decimated wavelet denoising at the command line. We have taken an medical image named “cancer” and the file type is jpeg. To perform the operation in the Wavelet 2-D–De-noising tool, we have to follow instructions as given below:

1. Enter wavemenu at the MATLAB command prompt.
2. Select Wavelet 2-D.
3. Load the Noisy SinSin example indexed image(i.e. Cancer image). Using the default biorthogonal 3.7 wavelet and level 2 decomposition, click analyze and then click denoise.
4. In the Select thresholding method drop-down menu, select the default Fixed form threshold and soft options. Use the default Unscaled white noise.
5. Now click on Denoise button shown on appeared window.
6. Save the denoised image in a folder located on the C:\Users\system_name\Documents\MATLAB search path in .mat file format. e.g. : “cancer.mat” .

VI. COMPRESSION IN WAVELET 2D

The Following instructions are used for the compression in Wavelet 2D:-

1. Enter the code “load cancer.mat” at the MATLAB command prompt.
2. Now to display the image use the functions colormap(map), colorbar, and image(I).
3. Then image should be shown with a colorbar, which shows that image is smooth or not. If image is smooth then proceed to the next step otherwise first change image to gray scale and then proceed.
4. Now to perform a single level wavelet decomposition use dwt2() functions to generate the co-efficient matrices[4,6].

This generates the coefficient matrices of the level-one approximation (cA1) and horizontal, vertical and diagonal details (cH1,cV1,cD1, respectively).

5. Now work on construction of the level-one approximation and details (A₁, H₁, V₁, and D₁) from the coefficients cA₁, cH₁, cV₁, and cD₁.
6. Then to display the results of the level 1 decomposition, use functions colormap(map), subplot(m,n,p), image(wcodemat(I)). In matlab command window coding. Where, colormap(map) describes the map of the scenario (image, plot etc.).

subplot(m, n, p) describes the subplotting spaces where forms of images to be placed and image(wcodemat(I)) is used to display a rescaled version of I leading to a clearer presentation of the details and approximations[4].

7. Then regenerate an image by single-level Inverse Wavelet Transform. To find the inverse transform, use idwt2() function. This reconstructs or synthesizes the original image from the coefficients of the level 1 approximation and details.
8. Now perform a multilevel wavelet decomposition. To perform a level 2 decomposition of the image (again using the bior3.7 wavelet), use function wavedec2(), e.g.:- [C, S] = wavedec2(X, 2, 'bior3.7'), where X is the original image matrix, and 2 is the level of decomposition. The coefficients of all the components of a second-level decomposition (that is, the second-level approximation and the first two levels of detail) are returned concatenated into one vector, C. Argument S is a bookkeeping matrix that keeps track of the sizes of each component[4,5].
9. Then Extract approximation and detail coefficients. To extract the level 2 approximation coefficients from C, use appcoef2(), function for bior3.7. To extract the first- and second-level detail coefficients from C, use the function detcoef2(); and the arguments can be taken as h, v or d, where the first argument ('h', 'v', or 'd') determines the type of detail (horizontal, vertical, diagonal) extracted, and the last argument determines the level[4].
10. Now Reconstruct the Level 2 approximation and the Level 1 and 2 details. To reconstruct the level 2 approximation from C, use the function wrcoef2(), To reconstruct the level 1 and 2 details from C, again use the function wrcoef2(). This reconstructs the level 1 and 2 details from c in bior3.7[4].
11. Now Display the results of a multilevel decomposition. To display the results of the level 2 decomposition, use the following functions :- colormap(map), subplot(m,n,p), image(wcodemat(I)), title('TITLE') we already know about the functions colormap(map), subplot(m,n,p); and image(wcodemat(I)), Title ('TITLE') is only used for giving headline titles for the identification and presentation like this is for horizontal or vertical or diagonal details or any approximation details etc[4].
12. Then reconstruct the original image from the multilevel decomposition. To reconstruct the original image from the wavelet decomposition structure, use the function :- waverec2(), This will help to reconstruct or synthesize the original image from the coefficients C of the multilevel decomposition[4].
13. Compress the image and display it. To compress the original image X, use the ddnecmp command to calculate the default parameters and the wdnecmp command to perform the actual compression.

Note that we pass in to wdnecmp the results of the decomposition (C and S). We also specify the bior3.7 wavelets, because we used this wavelet to perform the original analysis[4]. Finally, we specify the global thresholding option 'gbl'. To view the compressed image side by side with the original, use following functions :- colormap(map), subplot(m,n,p), image(I), title('TITLE'), axis square

image(Icomp), Here Icomp is taken for compressed image. And now we see that our compressed image is shown with our original image in the same axis side by side.

VII. EXPERIMENTAL RESULTS

1. Enter wavemenu at the MATLAB command prompt

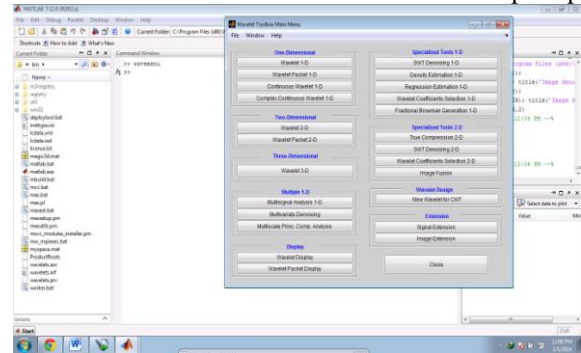


Fig-3 wavemenu

2. Select Wavelet 2-D

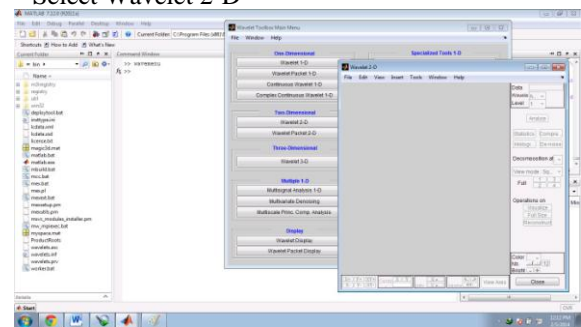


Fig-4 Wavelet 2D

3. Load the Noisy SinSin example indexed image i.e cancer image. Using the default biorthogonal wavelet and level 2 decomposition, click De-noise.

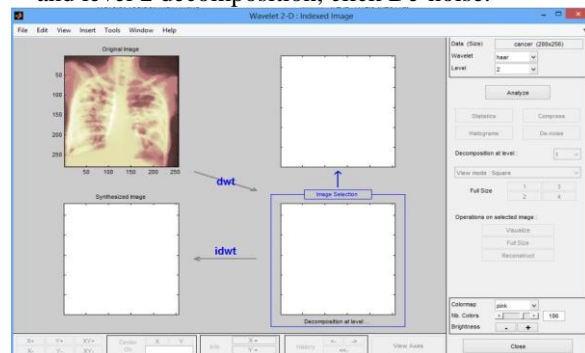


Fig-5 Indexed image

4. After clicking analyze button :-

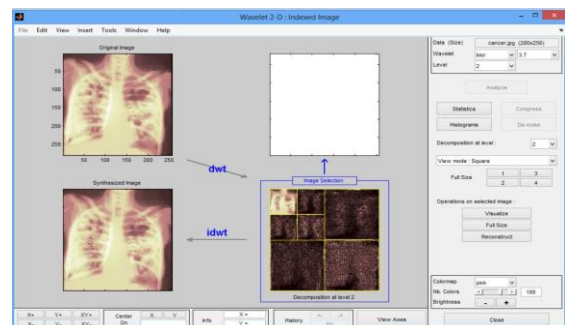


Fig-6 Analyzed image

5. After Denoising :-

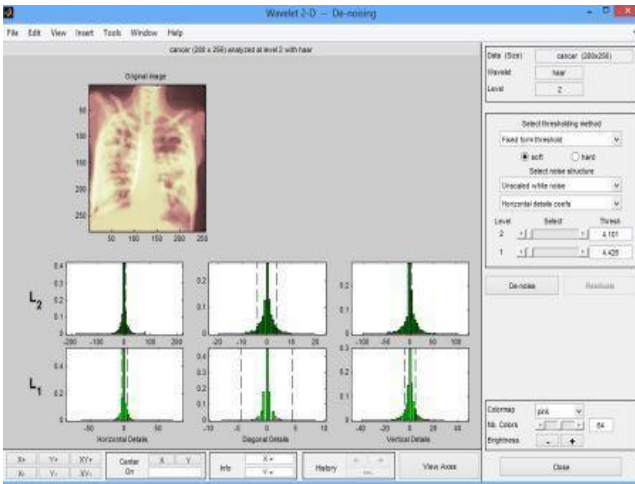


Fig-7 De-Noising

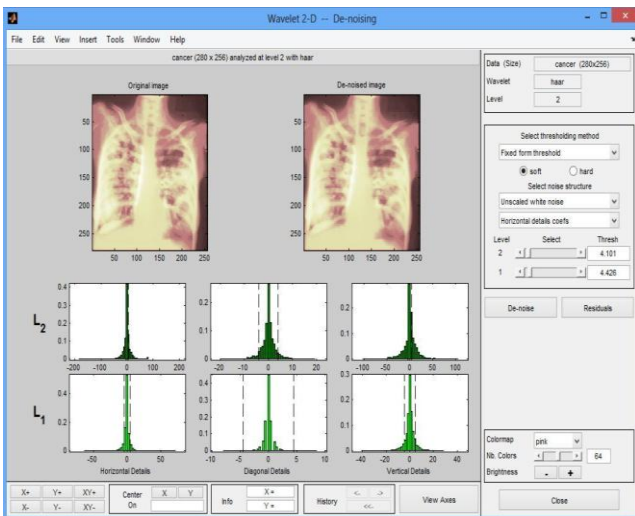


Fig-8 De-Noised Image

6. After saving the De-Noised image in .mat file format, we have loaded it again with using the code "load cancer.mat" on command window.
7. Now after displaying the image we have got the image with color map and color bar as :-

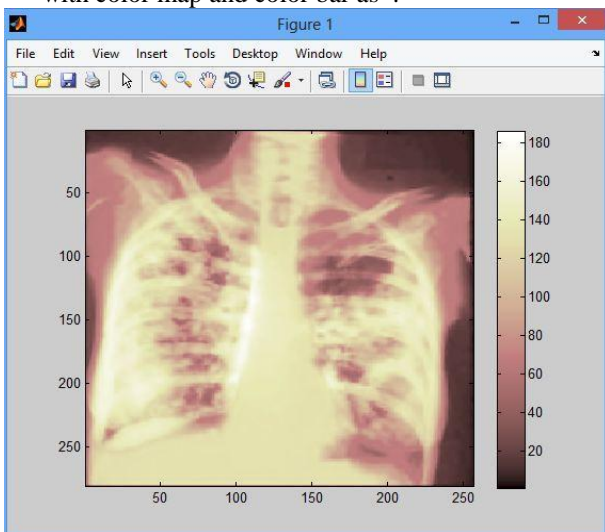


Fig-9.Shown Image

8. After Single level Decomposition the displayed image is :-

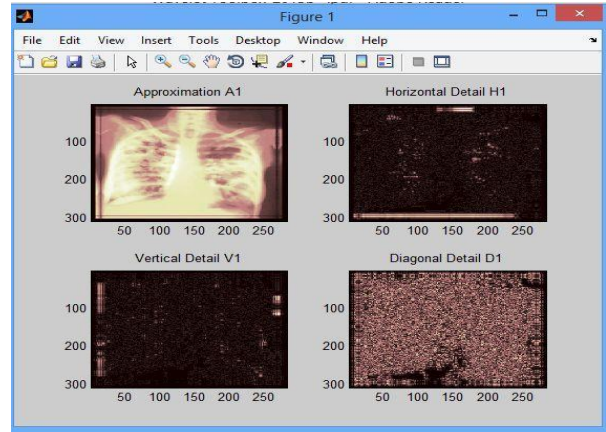


Fig-10.single level decomposed image

9. After Multilevel Decomposition the displayed image is :-

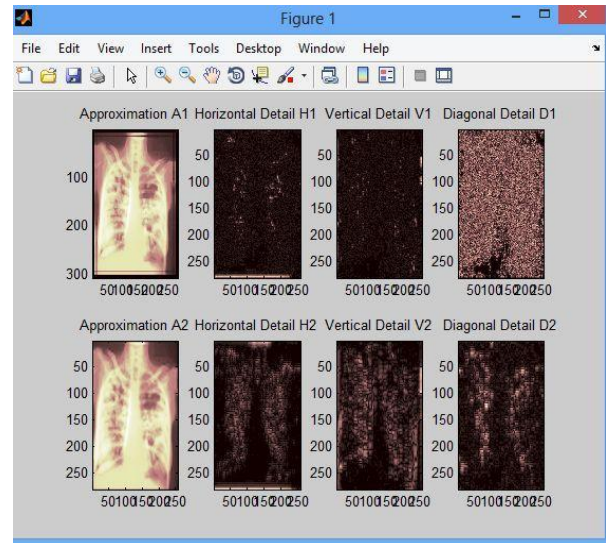


Fig-11. Multi level decomposed image

10. After compressing the image in the last steps of image compression the resulting compressed image is shown by :-

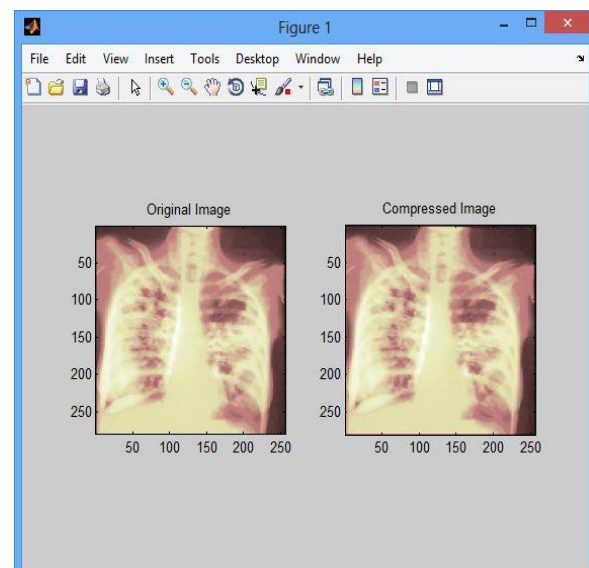


Fig-12. Compressed image

8. After Single level Decomposition the displayed image is :-

And Now We can retrieve our image file any time by loading that .mat file into command window of MATLAB.

VIII. CONCLUSION

In this paper we have taken a biomedical image for de-noising and compression in Wavelet Toolbox specially Wavelet 2D in MATLAB and MATLAB command prompt using step by step. As a result we get the compressed image as well as noise free in vertical, horizontal and diagonal details and got energy ratio. After doing this there is almost no detectable deterioration in the image quality. The statistics displayed in the above figure are related to the displayed image but not to the original one. Usually this information is the same, but in some cases, edge effects may cause the original image to be cropped slightly. We can generate MATLAB codes for all the operations like De-Noising, Decomposition, Compression etc.

IX. FUTURE WORK

In future work, we can denoise a biomedical image using different wavelets. We can do that making a different wavelet by us to get more and more noise free and compressed image. Here we have gone through level 2 decomposition, in future we can make it to level 3, 4 or more to be more accurate and clear. Here we have done it with bior 3.7 wavelet, whether in future we can try with other wavelets like haar, db, etc to get better results.

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