Ninth report - Denoising

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***Subject*— Multiresolution Analysis for Image Denoising using the Haar Wavelet**

I. Objective

The main goal of this study is to investigate the efficacy of the Haar Wavelet in image denoising and find optimal thresholds for noise removal.

A. Problem Description

Given a grayscale image with a maximum intensity value M, we apply the DWT on one level, introduce a threshold T, compute the PSNR of the reconstructed image, and plot PSNR as a function of T. The process is repeated with the noisy image and the noise level studied.

II. Methods

The study is conducted in two main steps: noise analysis with one level of multiresolution and two levels of multiresolution.

III. Methodology and Results

The grayscale image is first transformed using the Haar Wavelet. A threshold is applied, and the PSNR of the reconstructed image is calculated. This is done for a range of thresholds. The same process is repeated after adding Gaussian White Noise to the image. The optimal threshold is determined by the highest PSNR.

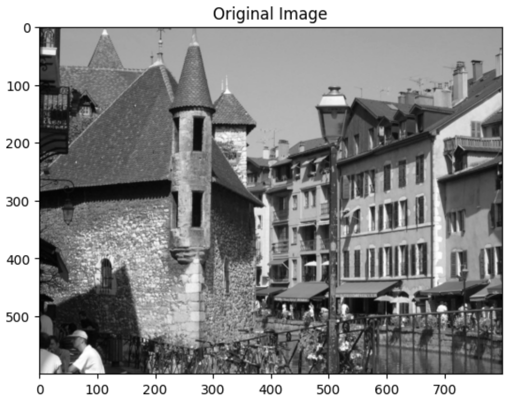

Fig. 1: The figure shows the Original image.

An the optimal threshold is 20.

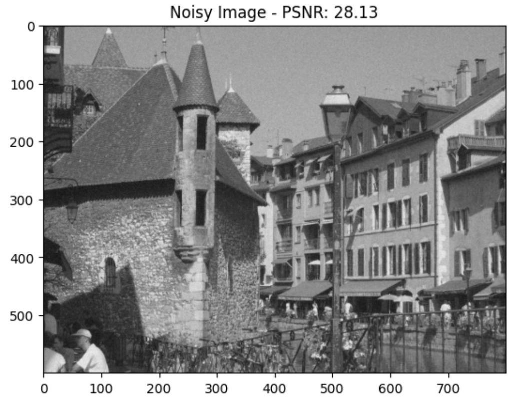

Fig. 2: The figure shows the Noisy image.

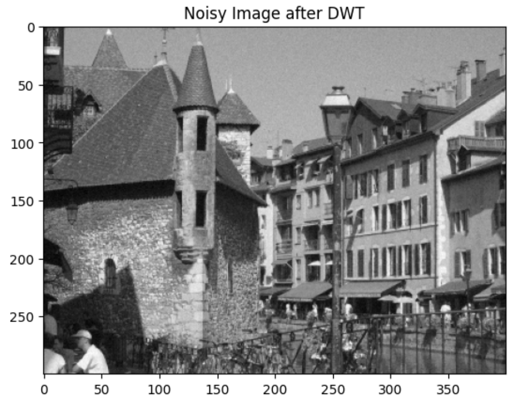

Fig. 3: The figure shows the Noisy image after the DWT.

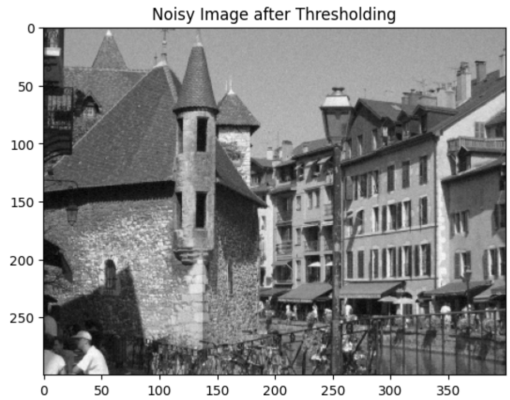

Fig. 4: The figure shows the Noisy image after the threshold.

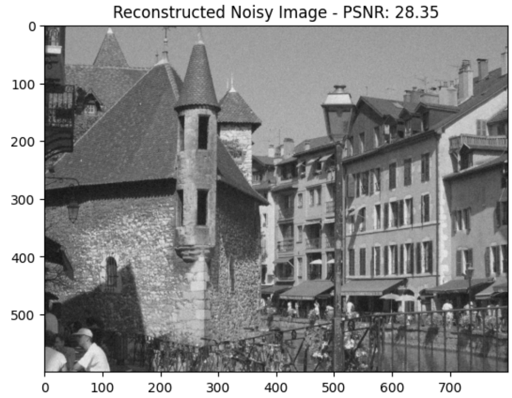

Fig. 5: The figure shows the reconstructed image.

We perform a noise analysis on an image by transforming discrete waves and thresholding. For various noise levels (0 to 50, in steps of 5), we add Gaussian noise to the image, then apply a wavelet transform and find the optimal threshold that maximizes the maximum signal-to-noise ratio (PSNR) between the original image and the reconstructed image. We then plotted the optimal threshold against the noise level to study their relationship.

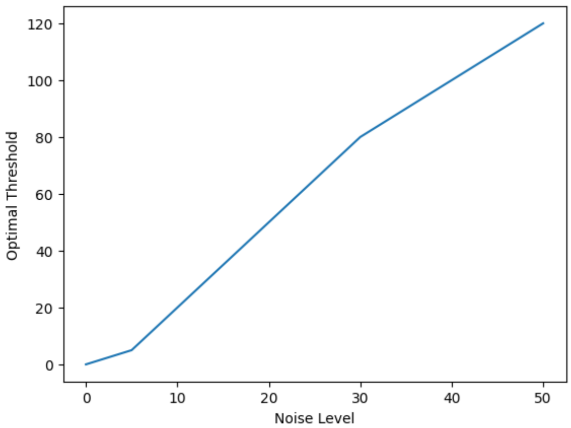

Fig. 6: Optimal Threshold vs Noise level.

In the end the relationship between the optimal thresholds for L1 ([0, 5, 20, 35, 50, 65, 80, 90, 100, 110, 120]) and L2 ([0, 5, 20, 35, 50, 70, 90, 110, 130, 145, 165]), it seems that as the noise level increases, so does the optimal threshold for both levels. However, the optimal threshold for L2 seems to grow faster than for L1. This could indicate that as the noise level increases, a higher threshold is needed to remove noise at the L2 level compared to the L1 level. This makes sense as L2 represents details at a finer scale than L1, so it is more likely to pick up more noise.

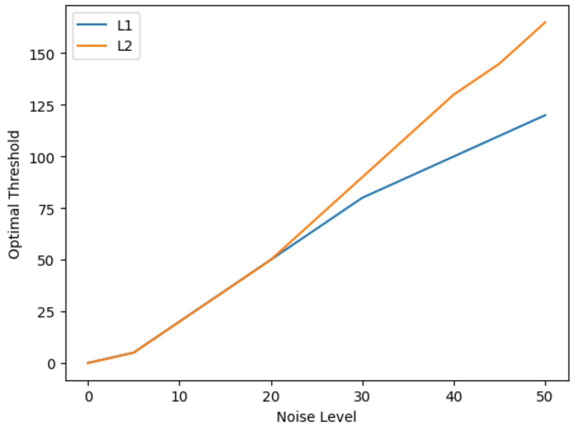

Fig. 7: Optimal thresholds vs Noisy Level(L1 and L2).

IV. CONCLUSIONS

In conclusion, this study explored the application of the Haar Wavelet for image denoising using multiresolution analysis. The Haar Wavelet demonstrated promising performance in reducing noise in grayscale images by separating the image into different frequency subbands. The optimal selection of thresholds played a crucial role in achieving high-quality denoising results, balancing noise reduction with the preservation of image details. The findings provide valuable insights for improving denoising techniques and advancing the field of image processing.

REFERENCES

[1] Mallat, S. (1999). A Wavelet Tour of Signal Processing: The Sparse Way. Academic Press.
[2] Donoho, D. L. (1995). De-noising by Soft-thresholding. IEEE Transactions on Information Theory, 41(3), 613-627.
[3] Chambolle, A., DeVore, R. (1998). Nonlinear Wavelet Image Processing: Variational Problems, Compression, and Noise Removal Through Wavelet Shrinkage. IEEE Transactions on Image Processing, 7(3), 319-335.