Abstract

This report corresponds to the evaluation of the obtained results in the sixth laboratory of Applied Harmonic Analysis.

1 Wavelets

In this exercise, we are asked to slightly attenuate the noise of an audio file. This exercise is close to laboratory 2, where we also explore the process of noise reduction in audio files. Nevertheless, it is important to notice that the noise introduced in this exercise is not of the same nature as the previous one, necessitating a distinct approach in our procedure.

The initial action performed by the script involves reading the audio file and playing it back. Following that, it introduces white noise[1] into the audio and plays it again. It is evident that there is a noticeable distinction between this newly added noise and the high-frequency noise encountered in the previous laboratory experiment.

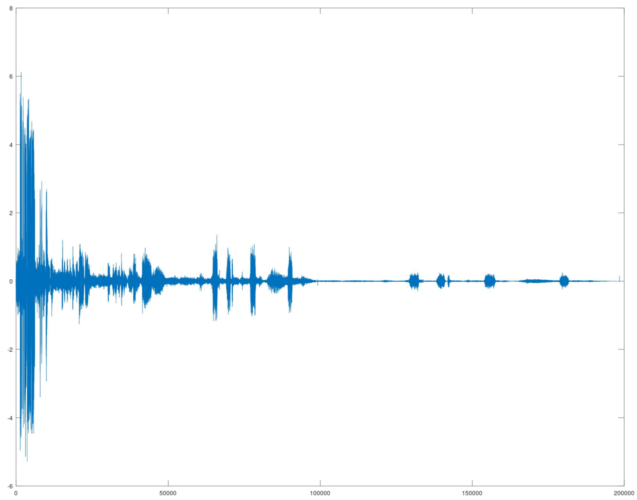
To effectively mitigate this particular type of noise, the recommended approach involves employing wavelets. The procedure requires computing the discrete wavelet transform and keeping only the most significant coefficients. The concept behind this is that, prior to introducing any noise, the coefficients with smaller values were already 0 (the noise makes them not zero). Therefore, we make the assumption that they are indeed 0 and retain only the coefficients with the greatest significance. Take note that we are encountering some degree of error, as even the highest coefficients exhibit some level of noise. However, we make the assumption and accept this error.

Returning to the script, we proceed by configuring several parameters such as the ratio for preservation, the number of levels, and analysis filters. These settings allow us to perform the Fast Wavelet Transform (FWT) on the given data. After the transformation, we retain the most significant coefficients based on the specified preservation ratio. Finally, we apply the Inverse Fast Wavelet Transform to restore the audio file to its original form.

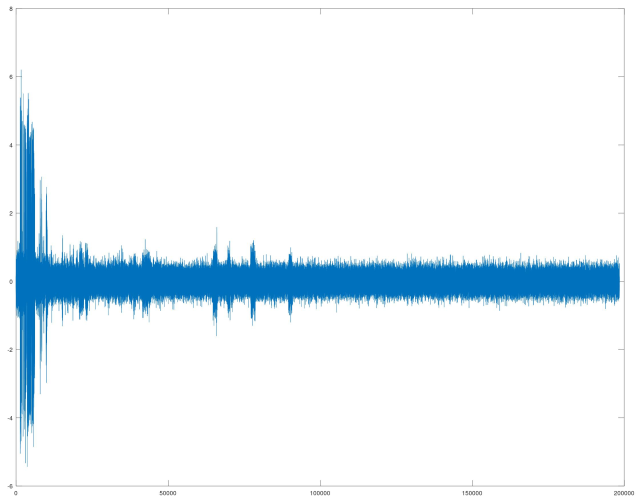
I have experimented with various preservation ratios to achieve optimal audio approximation. Through extensive analysis, it was determined that setting the ratio to 0.05 yields the most faithful representation of the original audio. In order to determine this value, I plotted the FWT for the original audio, the noisy audio, and the audio obtained by retaining only the largest coefficients, as depicted in Figure 1. It was observed that selecting a higher ratio value resulted in no coefficients being removed (or very few), whereas choosing a smaller ratio severely distorted (breaks) the audio, rendering the original content indiscernible to the listener.

As previously mentioned, this procedure differs significantly from the one employed in laboratory 2. It is important to recall that we successfully identified the high frequency that had been introduced and subsequently removed within the frequency domain.

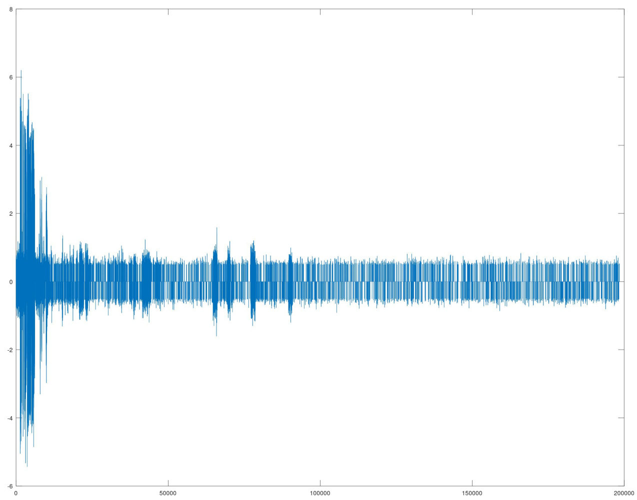
[1] White noise is a random signal having equal intensity at different frequencies, giving it a constant power spectral density.



(a) Original FWT audio.



(b) Noisy FWT audio.



(c) FWT after removing the noise.

Figure 1: FWT of different audio files.