EE-217
Final Project
Due Date: 12/04/2013

Final Project: "Hunt for Noise: Extracting Audio Information from Noisy Environment"

Objectives:

Goal was to search for noise sources of noise, which can interfere with useful audio signals, such as human conversation. The signals of these noise sources were to be recorded and then used in filtering signals, which were recorded with both, noise and speech signals.

Experiment data collection and processing:

Noise sources used for the project were: 5kHz sinusoidal signal, hair dryer, and water faucet. All of the noise signals were collected using an i-phone 4s voice-memo recording app. The signals were recorded for close to 5 seconds and stored as in .m4a file format. The sampling rate of the i-phone 4s microphone was 44.1kHz. Multiple recordings were taken for audio clarity, good noise to voice overlap, and optimal volume.

Three different approaches were taken in filtering the noise from the overlapping signal. First, the filter resembling a low pass filter was applied. This filter was supposed to filter out noise at higher frequencies and allow the passage of lower frequency signal. However, unlike ordinary LPF, this one was designed to fit the follow the magnitude to the voice recording, thus reducing the magnitude mostly of the noise signal. Second filter was designed such that the recorded noise was subtracted from the noise and voice signal. In this approach the recorded noise signal was expected to closely resemble the noise from the voice & noise signal, thus subtracting out most of the noise. Third approach was an attempt to discover frequency pockets where voice signal lied, thus filtering out every other frequency but these pockets.

Results and Discussion:

In the first approach a sample of the voice-recording signal in frequency domain was plotted together with the signal of voice and noise recording and the cut-off function as shown in figures 1 and 2. Figure 1 showed the signals with 1kHz noise and figure 2 showed the signal with hair dryer noise. Figure 3 showed the hair dryer signal after the cut-off filter was applied. Inverse Fast Fourier transform was then performed on this signal and the signal was converted back into the time domain, where it was played as a sound again. The results of the first approach were somewhat successful. The magnitude of the signal was easy to cut off and the signal was modified as desired, especially in the case of hair dryer signal. The modified signal did cut off the higher frequency noise as expected. This had made the voice easier to hear since the noise was less loud, lacking the high frequency part of the original noise. However, the noise overlapping the voice was still there and interfering with the voice signal.

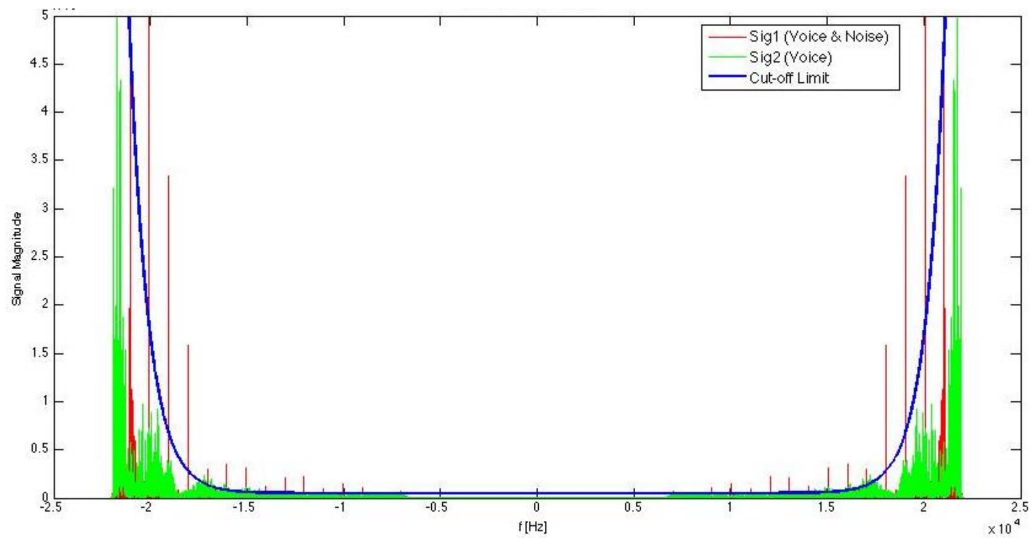

Figure 1. Approach 1 for 1kHz noise

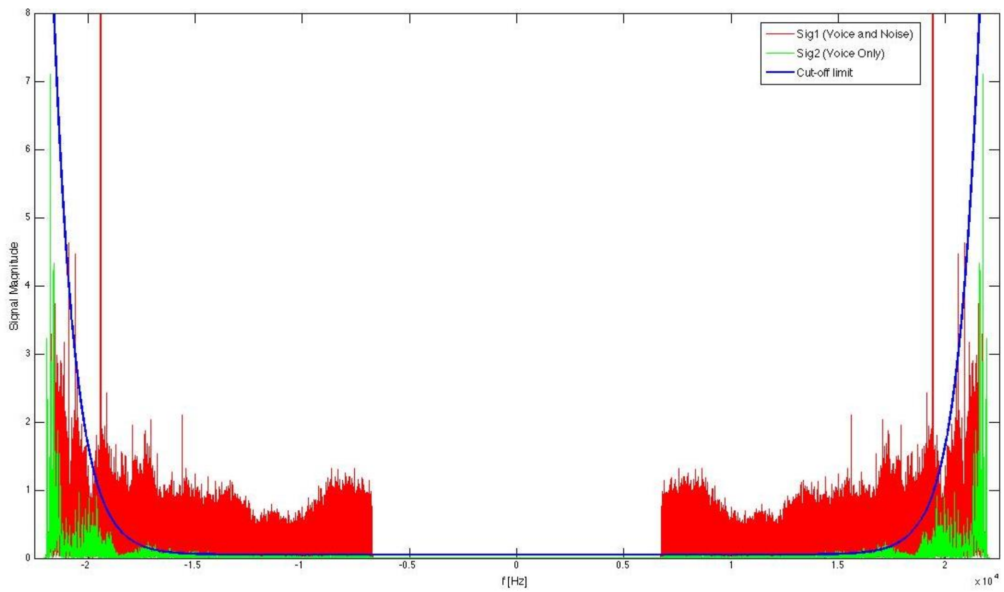

Figure 2. Voice and noise signal (red), with voice only signal (green) and cut-off limit (blue line), approach 1

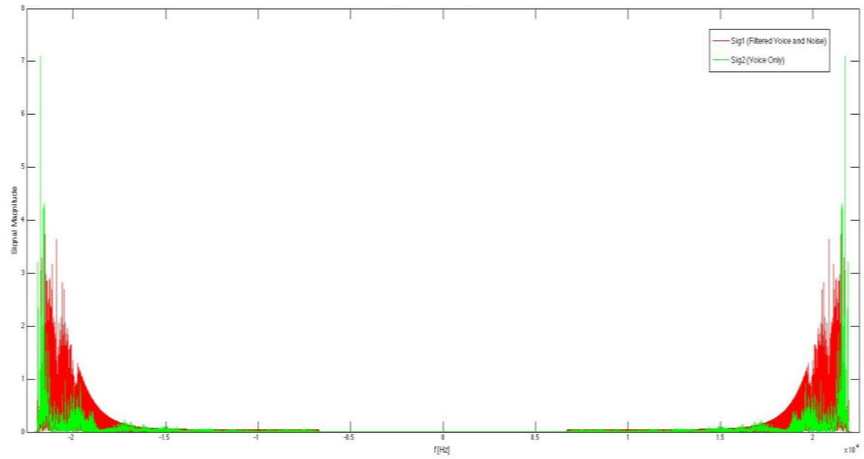

Figure 3. Hair dryer voice and noise signal after the cut-off filter was applied (red)

In the second approach to solving the problem, the recorded noise was simply subtracted in the frequency domain from the voice & noise signal. As figure 4 showed, the signal resulting from the subtraction did not look as expected. The voice within the noise had sounded distorted. It was expected for the magnitude of the noise to overlap, thus lowering the noise from the voice & noise signal, since the magnitudes were expected to be similar at certain frequencies. The resulting signal shown in blue in figure 4 was only slightly smaller in magnitude, but the shape stayed very similar to the original. Figure 4 represented data for hair dryer noise, but signals from 1kHz noise and faucet were very similar. In the signal with the hair dryer voice sounded much more high pitch than the original. Looking at the figure 4, this could have been explained by the fact that the resulting signal (blue) was somewhat lower in the low frequency area, but stayed mostly the same in the high frequency. This would have given the voice a higher pitch.

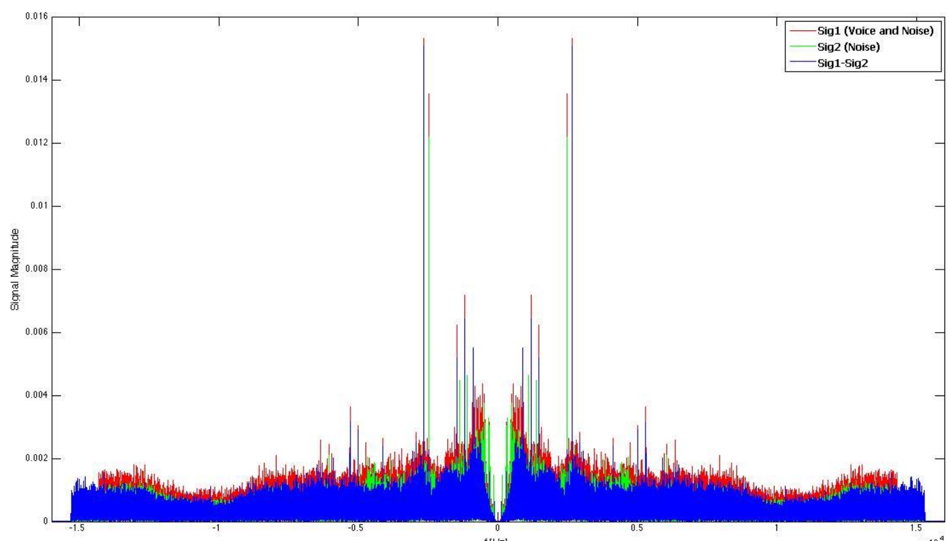

Figure 4. Approach 2 for the hair dryer noise

Third and final approach was an attempt to find only the important frequency pockets, where the voice lies. Once these are found the rest would have been discarded. This approach required for the signal to be listened to carefully across the spectrum, bit by bit. This approach was more tedious than the first two. The band pass filter had picked up the voice mostly in the low frequency area, where it was residing. However, when filtered this way the voice sounded much deeper than the original. Since it would have been hard to hear any high frequency voice signals, due to their low magnitude, the band pass filter cut them off. Without the higher frequency components, voice signal had to sound much deeper.

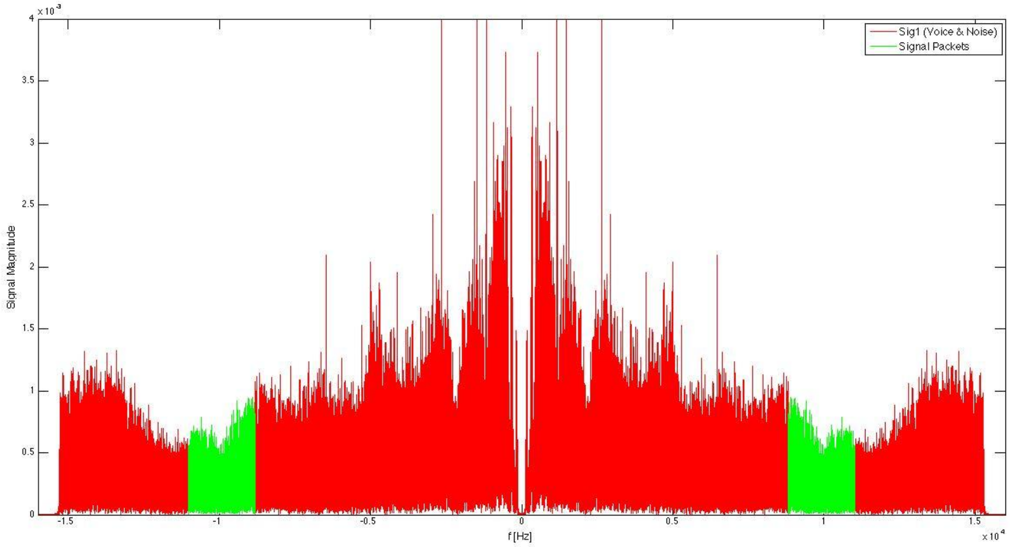

Figure 5. Approach 3 with hair dryer voice and noise signal

Conclusion:

This experiment was an attempt to separate valuable signal from noise of the similar frequency. Three different approaches to filtering the noise out were tried, but none have yielded any remarkable results. Most of the relative success was due to noise lying in the higher frequency range. This gave an opportunity to filter out much of the noise without hurting the voice signal. All of the approaches were an attempt to filter out noise in the frequency domain, but it would have been interesting to try and approach the filtering, signal modification in the time domain. Thus, the experiments have shed light on how difficult it was to separate real signals from noise when they overlap.