EECE 340 Project-Section 3.3 Error and Robustness Analysis

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Introduction

In this section, we examine how noise affects the sampling and reconstruction process. White Gaussian noise is added to both the filtered and unfiltered sampled signals before reconstruction. By reconstructing the noisy signals and comparing them to the original clean segment, we assess the impact of noise on reconstruction accuracy and evaluate the robustness of the system under noisy conditions.

MATLAB file description

Error_robustness.m:

performs an error and robustness analysis by evaluating how well a noisy sampled signal can be reconstructed. It starts by loading a previously recorded signal and extracting a 2-second segment between 3 and 5 seconds. The extracted segment is then filtered using a low-pass FIR filter using apply_lpf (note here we changed the cutoff frequency to 800Hz to amplify effects of filter).

Both signals are then sampled at 1800Hz. After sampling, white Gaussian noise is added to both sets of sampled data to simulate measurement or transmission noise. The noisy sampled signals are then reconstructed back to the continuous-time domain using the reconstruct code and then plotted.

Figures description

Figure 1: Reconstruction of noisy filtered sample

This figure displays the **reconstruction of a filtered voice signal from noisy sampled points**. We can see that although the reconstruction follows the general shape of the original filtered signal, the added noise causes visible deviations and fluctuations. The low-pass filter helps by removing high-frequency components, reducing the amount of noise and aliasing passed into the reconstruction.

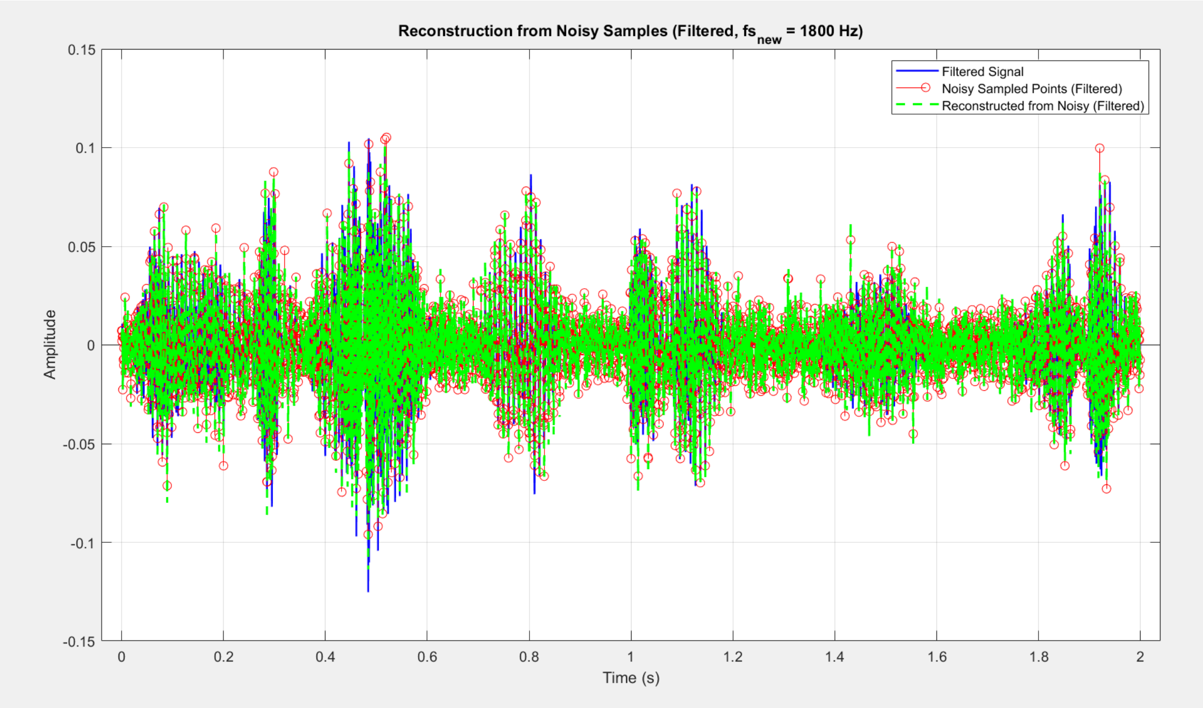
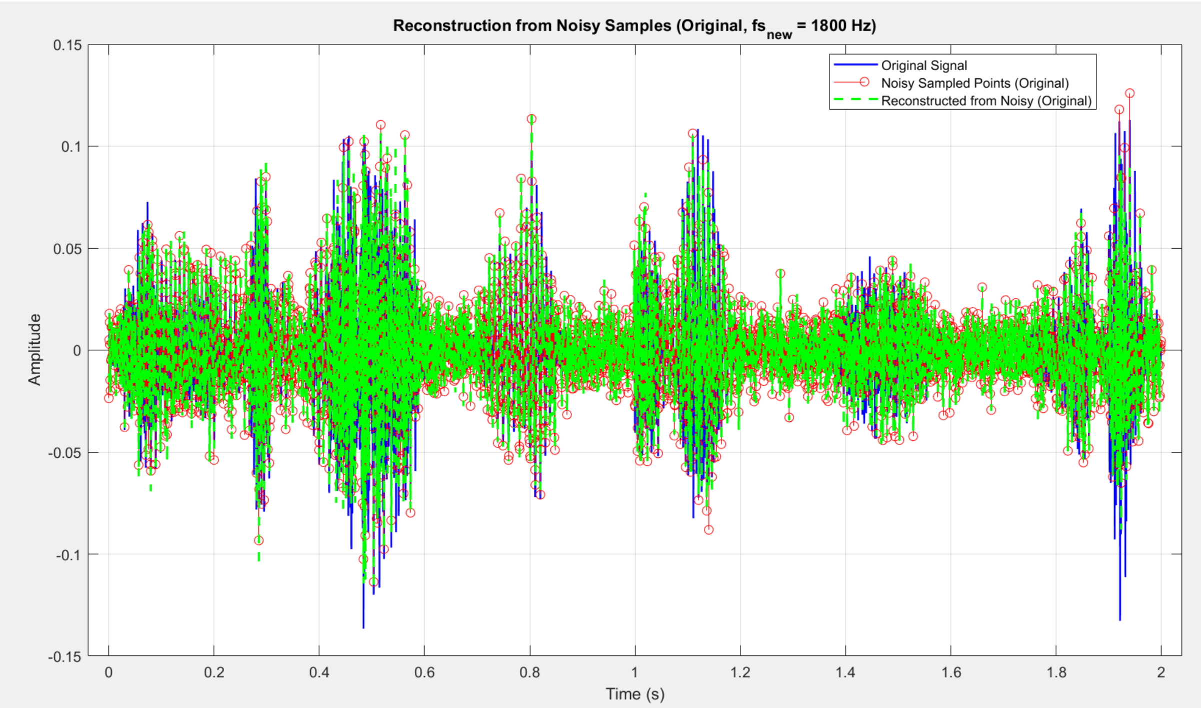


Figure 2: Reconstruction of noisy original sample

This figure shows the **reconstruction of the original (unfiltered) voice signal from noisy sampled points.** Compared to the reconstruction of the filtered signal, we can see that the reconstruction here still generally follows the original waveform but is **more visibly affected by noise, especially in regions with higher frequency content**. The reconstruction exhibits more fluctuations and distortion because the high-frequency components in the original signal amplify the noise during sampling and reconstruction.



Error and Robustness analysis

The added noise affected the reconstructed signal by introducing random fluctuations and reducing overall signal clarity. The noise increased the difficulty of accurately recovering the original waveform, leading to deviations from the true signal, especially in finer details**. This effect was particularly evident in low-frequency regions corresponding to pauses or soft speech**. The filtered signal, having had its high-frequency components removed prior to sampling, exhibited better robustness against noise. It preserved the main structure of the original speech with less distortion and lower reconstruction error than the non-filtered signal. On the other hand, the non-filtered signal, which retained higher frequencies and therefore a broader bandwidth, was more susceptible to noise and aliasing. This resulted in a noticeably noisier and less accurate reconstruction. These observations highlight the critical role of filtering in improving signal fidelity and minimizing the impact of noise, especially when operating at lower sampling rates.