EECE 340 Project - Section 2.4 Noise Robustness

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Introduction

In this section, we investigate the impact of adding white Gaussian noise to a sampled signal and how it affects signal reconstruction using sinc interpolation. The goal is to evaluate how sampling rate influences robustness to noise and to explore trade-offs between sampling frequency and signal fidelity.

MATLAB Files Description

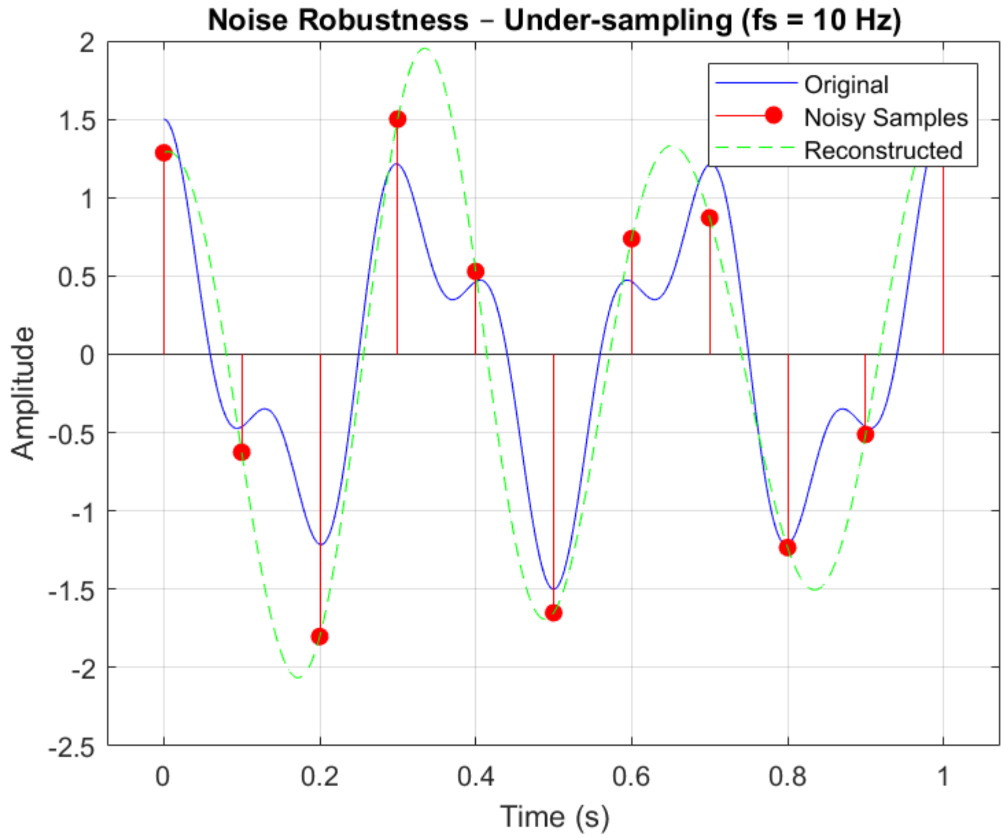
noise_robustness_updated.m:
This script generates a smooth signal composed of two cosine waves and tests reconstruction performance after adding Gaussian noise. It includes three sampling frequencies:
- 10 Hz (under-sampling)
- 14 Hz (critical sampling / Nyquist rate)
- 20 Hz (over-sampling)

For each case, the noisy sampled signal is reconstructed and compared to the original to assess reconstruction quality.

Noise Robustness Results

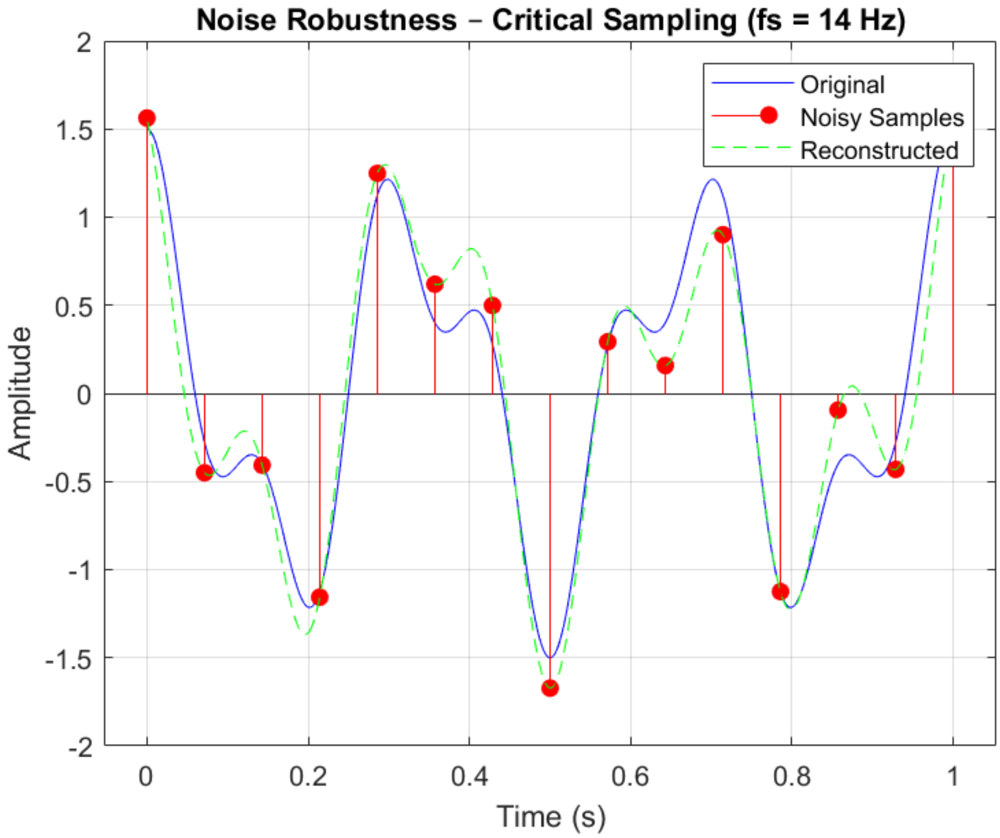
Case 1: Under-sampling (fs = 10 Hz)

Adding noise at a low sampling rate results in poor reconstruction. The sparse sampling makes it harder to recover the original signal, and noise greatly degrades quality.



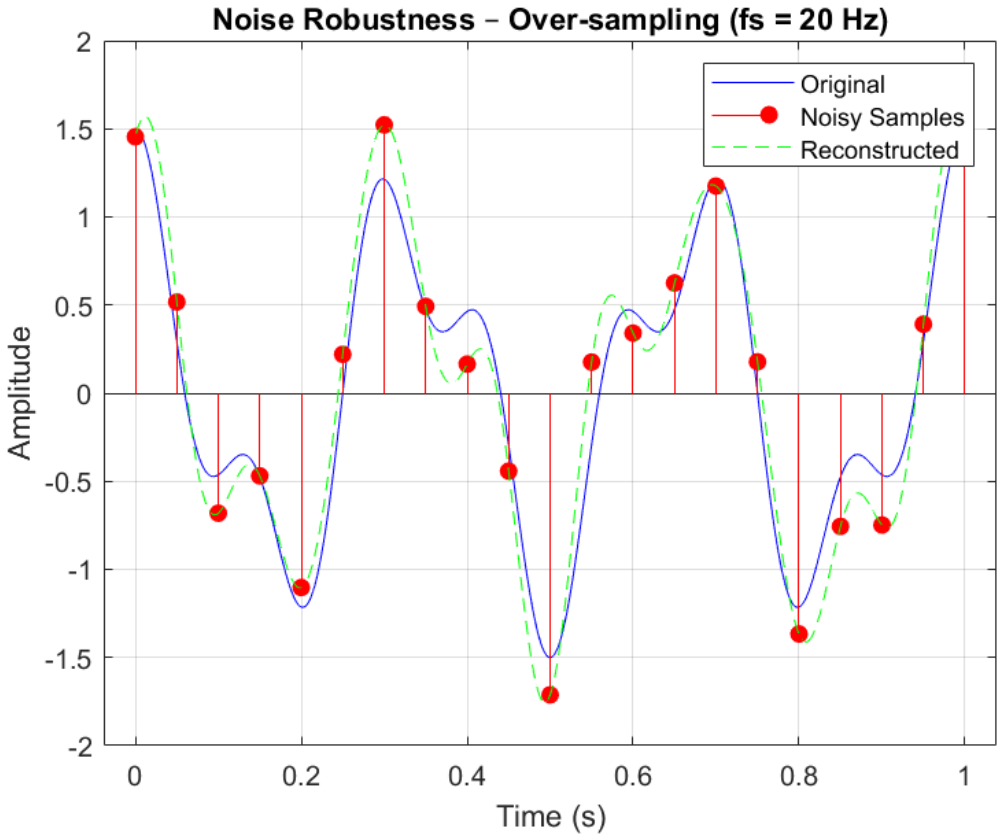
Case 2: Critical Sampling (fs = 14 Hz)

At the Nyquist rate (2 × fmax), the reconstructed signal improves noticeably. Although noise is still present, the sampling rate is sufficient to capture the signal shape.



Case 3: Over-sampling (fs = 20 Hz)

Over-sampling provides additional robustness to noise. The reconstruction is very close to the original, and noise effects are significantly reduced.



Conclusion

Noise robustness improves with increased sampling rate. Under-sampling leads to poor recovery of the original signal in noisy conditions. Sampling at the Nyquist rate reduces distortion, and over-sampling enhances accuracy and resilience to noise. Designers must weigh sampling cost versus desired signal fidelity.