Homework Assignment 5
Interpolation Filters for Upsampling

ECEN 463 - Digital Signal Processing
University of Nebraska-Lincoln
Instructor: Maxx Seminario

Due: November 24, 2025

Assignment Overview

This homework assignment focuses on interpolation filters for upsampling digital audio signals. You will implement and compare various interpolation techniques, analyze their frequency responses, and evaluate their performance through both objective plots and subjective listening tests.

Instructions

- Complete all programming tasks with detailed MATLAB implementation

- Submit your solutions as a **single PDF report** via Canvas

- Attach your **MATLAB code as a separate document or as appendix**

- Include labeled plots with time-aligned signal segments

- Provide concise descriptions of audio quality and observations

- IEEE formatting templates available at: `https://www.ieee.org/conferences/publishing/templates.html`

Problem Statement

Write a MATLAB program to read and upsample the provided `voice_samp_8k.wav` file (sampled at $F_s = 8000$ samples per second) by an integer factor L (choose a value in the range 3 to 7).

Required Implementations

Implement and compare the following five interpolation approaches:

(i) **No Interpolation Filtering:** Upsample only with zero insertion, no filtering

(ii) **Hold Interpolation:** Implement as a causal FIR filter - you may use the `filter()` function

(iii) **Linear Interpolation:** Implement as a causal FIR filter using - you may use the `filter()` function

(iv) **Short FIR Lowpass Filter:** Design a shorter FIR interpolation filter ($\sim$20–200 taps) - you may use `fir1()`

(v) **Long FIR Lowpass Filter:** Design a longer FIR interpolation filter ($\sim$200–2000 taps) - you may use `fir1()`

Analysis Requirements

For each interpolation method:

- Listen to the output using `soundsc()`

- Plot short segments ($\sim$50–100 samples) of the output signals

- Create time-aligned plots comparing all five methods

- Plot frequency responses using `freqz()` where applicable

Report Requirements

Your write-up should include:

- Description of the sounds heard for each interpolation approach

- Analysis of the time-aligned output segment plots

- Discussion of frequency response characteristics

- Any interesting observations about filter performance

- Comparison of computational complexity vs. audio quality

Additional Notes

- The value of concision (complete and brief) is important in technical writing

- Bring questions to class for discussion

- Consider: "What do you mean by time-aligned plot?"

- Ensure all plots are properly labeled with axes, titles, and legends

Academic Integrity

This is an individual assignment. While you may discuss general concepts with classmates, all submitted work must be your own. Copying solutions from other students, online sources, or solution manuals constitutes academic dishonesty and will result in a failing grade for the assignment.