ESE 351 Case Study Report Guidelines

Loosely based on report guidelines for ESE 498/499 Capstone projects, including some content from Hiro Mukai (retired Professor and Associate Chair, ESE), and Sandra Matteucci (Director, Engineering Communications, and Instructor, Technical communications), as well as Case Study 1 Reports in ESE 351 Fall 2020

Overall

- Format
  - [IEEE two-column](#)enforces concise writing
  - Main content (text and figures) in 4 pages
  - Use appendix or supplementary material to include other details
  - If using IEEE style header, could replace with ‘ESE 351 Case Study #1 Multi-band equalizer’

From Classical Music to Chill Electronic Pop: Modeling a Multi-Band Equalizer to Filter Noise within Various Digital Audio Files

Leo Karp, Tillman James, and David Papermaster

Abstract— Noisy recordings are the bane of every music producer and consumer. Commonly solved using equalizers, our study aims to implement custom equalizers as a system of signal processing techniques in MATLAB. The building blocks of signal processing are filters, a frequency dependent transformation used to isolate desired frequencies from a given signal. Implementing a system of multiple filters in parallel extend the isolation properties of a single filter to multiple, separate ranges. By taking advantage of graphical analysis techniques alongside simple trial and error, we were able to devise a technique for removing unwanted noise from audio recordings.

I. Background

Digital audio filtration is a frequency dependent system designed to achieve a desired attenuation of a given signal. Here we utilized Fourier Transforms and MATLAB to simulate an audio filtration system in order to remove a desired noise from the initial audio signal. Fourier Transforms were used to analyze the given signal is the frequency domain to observe where the specific noise remains. MATLAB was used to simulate the audio filter using the Butterworth filter function of sixth order. The Butterworth Fucntion allows the user to model a simple high pass, lowpass, bandpass, and bandstop system with specified frequencies. For the creative portion of our Study we aimed to remove a background rain noise from a snippet of Lo-Fi music. Lo-Fi music is a style of relaxed electronic pop that can help with extended periods of concentration as well as a mood setting for certain afternoon hang out sessions. Our snippet contains a constant background rain of various frequencies that our designed filter removed. A Bode plot and impulse response were generated from this to obtain defining characteristics of the filter.

II. Methods

A. G-Scale on Violin

My method for processing the G-scale on a violin with audible background noise consisted of a system of parallel bandpass filters. In order to determine the respective frequency ranges for each filter, I first analyzed the frequency content of the given audio. Evaluating the spectrogram, it is clear that there is significant power in the 0-1000 Hz range throughout the entire audio file. I believed this to be an indicator for the low frequency fan noise. To begin isolating the desired sound, I first implemented a high pass filter with a very low cutoff frequency. By incrementally increasing the cutoff frequency, I could determine the upper bound of the noise frequency range. Using this first frequency to isolate the lower range of noise frequency, I implemented a bandpass filter surrounding this newly found approximate range 1000 - 1750 Hz. Repeating the frequency sweep with a low pass filter in parallel with the bandpass filter, I began to tune and filter out the higher frequency range of noise 2500 - 3000 Hz. I found that the majority of the desired violin sounds occurred within the range 1750 - 2500 Hz, so I began to tune the gain values of each of the respective bandpass designated filters. To emphasize the desired violin notes while decreasing noise, I decreased the gains to -6 dB of both noise focused band pass filters and increased the violin focused bandpass to +2 dB. While determining the frequency ranges, I determined to stop incrementing by using my best judgement in comparing an increase or decrease with the previous iteration until a satisfactory audio was reached.

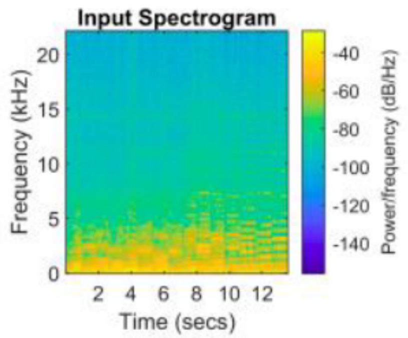


Figure 1: Spectrogram of unprocessed Violin audio signal.

B. Ode to Joy – Beethoven's 9th Symphony

In order to filter the sound file containing the Finale of Beethoven's 9th Symphony, the same framework as the filter

Figures (and tables)

- Include block diagrams, figures and tables where appropriate to describe your problem, methods, and results
- Include captions and figure/table numbers for all
- Mention your tables and figures in the body of the text
- Use font sizes and line widths appropriate to figure size on the page
- Label all axes and include legends when needed

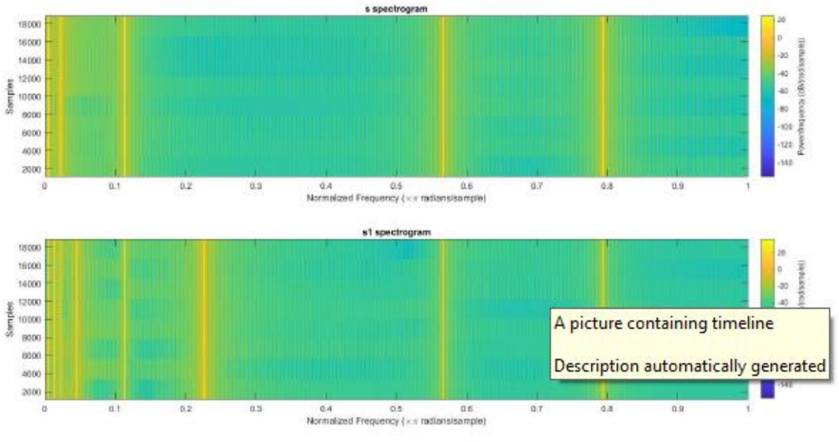
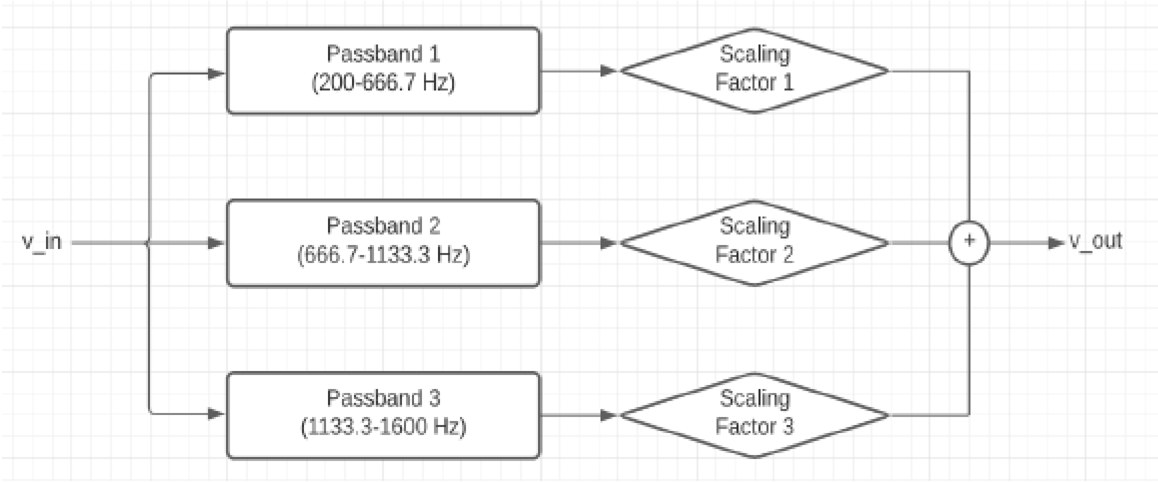


Fig.10 spectrogram of s and s1.

Gao



Dale, Rinder, and Serpen

Methods (technical approaches)

- Describe how you approached your design objectives
- Be specific (within page limit constraints)
- Include key equations, and define all variables
- Can include description of data in this section
- If an approach did not perform as expected, or did not meet the specifications, what alternative approaches were considered and/or attempted?

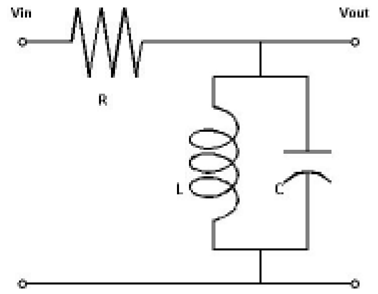


Fig 2.3 Bandpass RLC Circuit

Alcantara, Dai, Oestrich

Results

- The results are the heart of your project.
  - They should demonstrate the performance of your design and provide evidence of how well you were able to meet the specifications of the project.
  - They illustrate the operation of your design and your methods.
- Where possible, organize results in tables and figures to summarize cleanly the most important results.
- Include interpretation of the data to lead the reader from concept to concept.

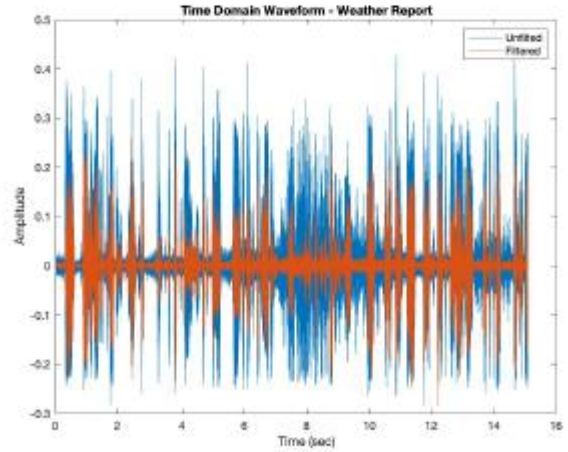


Fig. 9. Unfiltered and filtered waveform of hurricane Laura weather report signal in the time domain.

Kosins, Ni

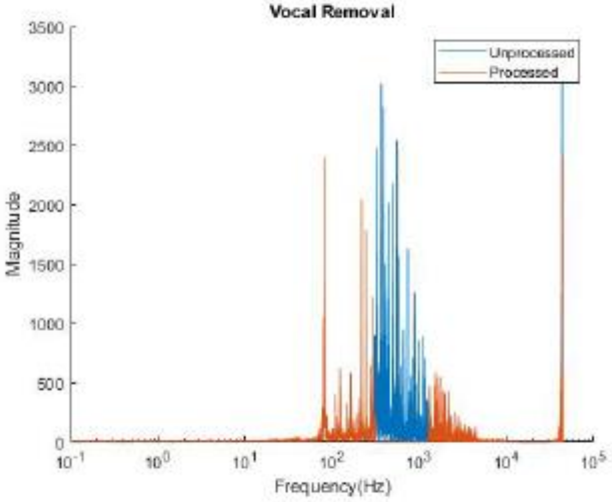


Figure 5: Vocal Removal: Processed vs Unprocessed

Croxford, Jakiela, Wu

Background

- Only brief background is needed for these case studies
- Introduce relevance of the problem, basic problem statement, and objectives of the project

Conclusions

- Highlight main findings of the project
- Can include brief discussion (usually a separate section in a longer report)

Title

Notes

- Creates a first impression
- Influences a reader to continue reading
- Conveys topic appropriately and fully
- Be specific
- Avoid unnecessary words, “A study of…”
- Keep it short: 10-12 words
- Start with a draft/working title and revisit again at the project end

Case Study 1 Example:

- “From Classical Music to Chill Electronic Pop: Modeling a Multi-Band Equalizer to Filter Noise within Various Digital Audio Files”, James, Karp, Papermaster

Abstract (~100-200 words)

- An abstract provides a stand-alone summary of your project; a reader should be able to get an idea of your project from the abstract alone. Try to be as specific as possible within the word constraint, while only including significant details. The abstract should
  - Introduce the problem to be solved or addressed
  - Describe what you have done to design a solution to part or all of the problem
  - Describe any technical methods you have used
  - State the results you have found