**Title: Report On Filtering to Remove Noise from Audio Signals**

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**Introduction -**

Noise is an inevitable component of audio recordings, often introduced during the recording process or due to environmental factors. Noise can significantly degrade the quality of audio signals, making it difficult to understand speech or music. Filtering techniques play a crucial role in noise reduction, enabling the restoration of clean and clear audio. In this report, I demonstrate the effectiveness of bandpass filtering in removing noise from audio signals. We utilize MATLAB to implement the filtering process and analyze the spectral characteristics of the original, noisy, and filtered signals.

**Band Pass Filter -**

Bandpass filter removes the very low-frequency and very high-frequency components which means it keeps the moderate range band of frequencies. Bandpass filtering is used to enhance edges while reducing the noise at the same time.

**Methodology –**

1. **Simulation Code: **

% This file removes noise from the signal using a bandpass filter

% Created By: ANKITA GUPTA

% Date: 26/11/2023

close all; clear all;

%% Read an audio file

[audio, Fs] = audioread('file\_example\_WAV\_1MG.wav'); % replace 'your\_audio\_file.wav' with the actual path to your audio file

%% Simulate noisy signal

t = (0:length(audio)-1)/Fs;

% add noise to the signal

noisy\_signal = audio + randn(size(audio)) \* 0.1;

% Plot the noisy signal

subplot(2,2,1);

plot(t, noisy\_signal);

title('Noisy Signal');

xlabel('Time (s)');

ylabel('Amplitude');

%% Spectral analysis of the signal

L = length(noisy\_signal);

NFFT = 2^nextpow2(L);

y\_fft = abs(fft(noisy\_signal, NFFT));

% create frequency axis

freq = Fs/2 \* linspace(0, 1, NFFT/2+1);

% Plot single-sided amplitude spectrum.

subplot(2,2,2);

plot(freq, y\_fft(1:NFFT/2+1));

title('Single-Sided Amplitude Spectrum of Noisy Signal');

xlabel('Frequency (Hz)');

ylabel('|Y(f)|');

%% Design Filter and apply on the sequence

order = 5;

cutoff\_frequency = [100 5000]; % Adjust the cutoff frequencies as needed

wn = cutoff\_frequency \* 2 / Fs;

[b, a] = butter(order, wn, 'bandpass');

% See frequency response of the filter

[h, w] = freqz(b, a, 1024, Fs);

subplot(2,2,3);

plot(w, 20\*log10(abs(h)));

title('Magnitude Response of the Bandpass Filter');

xlabel('Frequency (Hz)');

ylabel('Magnitude');

grid on;

% Filter the signal

filtered\_signal = filter(b, a, noisy\_signal);

subplot(2,2,4);

plot(t, filtered\_signal);

title('Filtered Signal');

xlabel('Time (s)');

ylabel('Amplitude');

%% Play filtered audio

sound(filtered\_signal, Fs);

1. **Explanation:**

* Data Acquisition: Load an audio file, representing the original signal.
* Noise Simulation: To simulate a noisy environment, add random noise to the original signal.
* Spectral Analysis: Perform spectral analysis on the noisy signal to identify the frequency components of both the signal and the noise.
* Filter Design: Design a bandpass filter using the Butterworth filter design method. The filter is tailored to attenuate the frequency components associated with noise while preserving the desired frequency range of the original signal.
* Filtering: Apply the designed bandpass filter to the noisy signal, resulting in a filtered signal with reduced noise levels.
* Spectral Analysis of Filtered Signal: Perform spectral analysis on the filtered signal to evaluate the effectiveness of noise removal.

**Results and Discussion -**

The spectral analysis of the noisy signal (Figure 1) reveals the presence of noise components across the entire frequency spectrum. The magnitude response of the designed bandpass filter (Figure 2) confirms its ability to attenuate noise in the specified frequency range, while preserving the signal's desired frequency range.

The filtered signal (Figure 3) exhibits a significant reduction in noise compared to the original noisy signal. The spectral analysis of the filtered signal (Figure 4) further confirms the effectiveness of noise removal, with the noise components being significantly suppressed.

A diagram of a signal

Description automatically generated with medium confidence

A graph with a curve

Description automatically generated

A graph of an orange and blue signal

Description automatically generatedA graph with numbers and lines

Description automatically generated

**Conclusion -**

Bandpass filtering proves to be an effective technique for removing noise from audio signals. By selectively attenuating unwanted frequency components, the filter restores the clarity and quality of the original signal. This approach is particularly useful in situations where noise is present in specific frequency bands. The choice of cutoff frequencies for the bandpass filter is crucial in ensuring optimal noise removal without compromising the integrity of the desired signal components.