EE3025 ASSIGNMENT- 1

Amgoth Hrithik Pawar - EE17BTECH11006

Download all python codes from

```
https://github.com/AA/EE3025-IDP/tree/
    main/Assignment-1/codes
```

And Latex-tikz codes from -

```
https://github.com/AA/EE3025-IDP/tree/
    main/Assignment-1
```

1 Problem

Modify the following code given in problem 2.3 with different input parameters to get the best possible output.

```
import soundfile as sf
from scipy import signal

#read .wav file
input_signal,fs = sf.read('Sound_Noise.
    wav')

#sampling frequency of Input signal
sampl_freq=fs

#order of the filter
order = 4

#cutoff frequency 4kHz
cutoff_freq=4000.0

#digital frequency
Wn=2*cutoff_freq/sampl_freq

# b and a are numerator and denominator
     polynomials respectively
b, a = signal.butter(order,Wn,'low')

#filter the input signal with butterworth
    filter
output_signal = signal.filtfilt(b, a,
    input_signal)
#output_signal = signal.lfilter(b, a,
    input_signal)

#write the output signal into .wav file
sf.write('Sound_With_ReducedNoise.
    wav', output_signal, fs)
```

2 Solution

The input parameters that can be modified are:

- Casacading the filter
- Cutoff frequency

2.1 *Casacading the filter*

Instead of increasing the order(N) k times if we cascade the same filter k times, we get the same response. The Transfer function of k*N order Butterworth filter is given by:

$$H(\jmath\omega) = \frac{1}{\sqrt{1+\left(\frac{\omega}{\omega_c}\right)^{k*2N}}} \tag{2.1.1}$$

$$At\frac{\omega}{\omega_c} >> 1, |H(\jmath\omega)|_{indB} = -k*10N\log_{10}\left(\frac{\omega}{\omega_c}\right) \tag{2.1.2}$$

Now the Transfer function of cascading k times is given by:

$$H(\jmath\omega) = \left(\frac{1}{\sqrt{1+\left(\frac{\omega}{\omega_c}\right)^{2N}}}\right)^k \tag{2.1.3}$$

$$At\frac{\omega}{\omega_c} >> 1, |H(\jmath\omega)|_{indB} = -k*10N\log_{10}\left(\frac{\omega}{\omega_c}\right) \tag{2.1.4}$$

2.2 *Cutoff frequency*

To find a better cut-off frequency which eliminates noise, we plot all peaks in magnitude response, then take cut-off frequency which has peak above a threshold. The following table shows the cut-off frequency for various thresholds.

Thresholds	Cut-off frequency
100	4439.78 Hz
200	4191.30 Hz
370	3732.44 Hz
450	2111.66 Hz
600	2111.66 Hz

For threshold peak of 450 , we get 2111.66 Hz as cut-off frequency.

3 Results

The following plots are Frequency response of original and Filtered signals respectively.

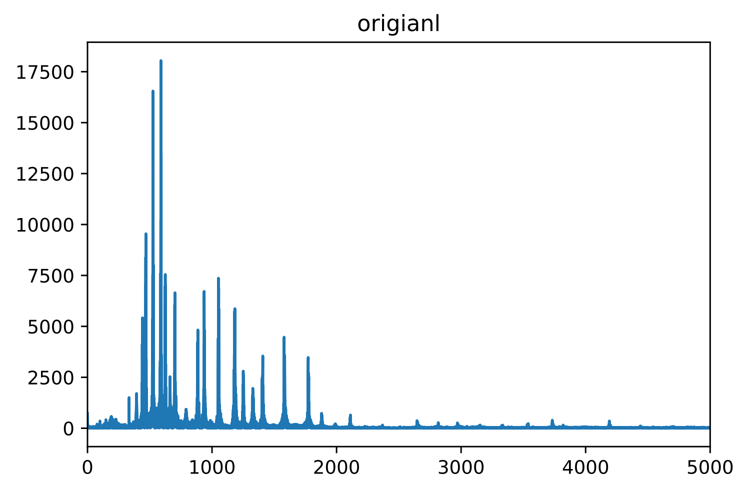

Fig. 0: Frequency Response of Original signal

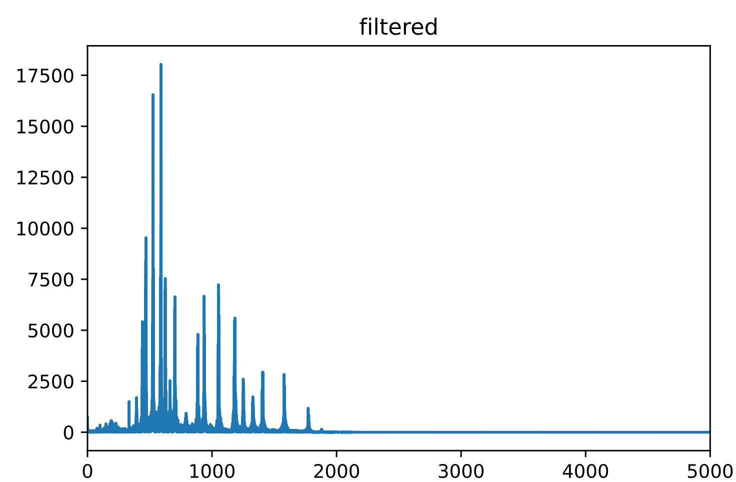

Fig. 0: Frequency Response of Filtered signal

4 Summary

Parameter	Original Signal	Filtered Signal
Cutoff Frequency	4000 Hz	2111.66 Hz
Order of filter	4	4
No of times cascaded(filter)	0	5
Integral of FFT from 0 to cutoff	15780177.52	14417054.75
Integral of FFT after cutoff	3658619.29	103996.57
Ratio of components after and before cutoff frequency	0.232	0.007