Report on assignement 5 of Data Capture and Processinig course

Hamza Omari[1*]

[1*]faculty of science and technology, University Paris est Créteil, Créteil, 94100, France.

Corresponding author(s). E-mail(s): hamza.omari@etu.u-pec.fr;

Abstract

In this report we will focus on of filtering a voice signal using both Infinite Impulse Response (IIR) and Finite Impulse Response (FIR) filters. The goal is to analyze the effectiveness of these filters .

Keywords: Voice processing, IIR, FIR, Signal processing

1 Voice signal acquisition

We start by the acquisition of the voice signal using an online voice recorder [1]. The recording tool, uses a frequency of 48kHZ, we will resample it for a frequency of 44,1 kHZ

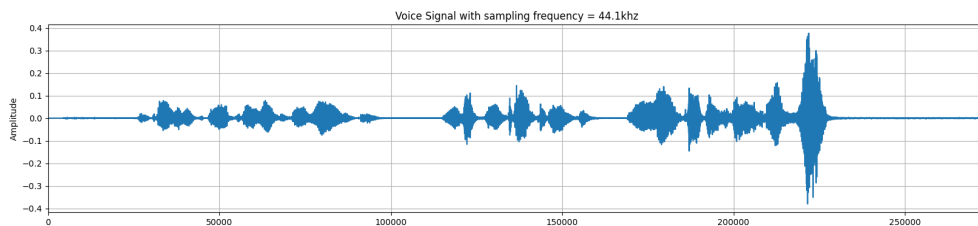The recorded sampled voice is shown in the figure 1

Fig. 1: Recorded Voice signal

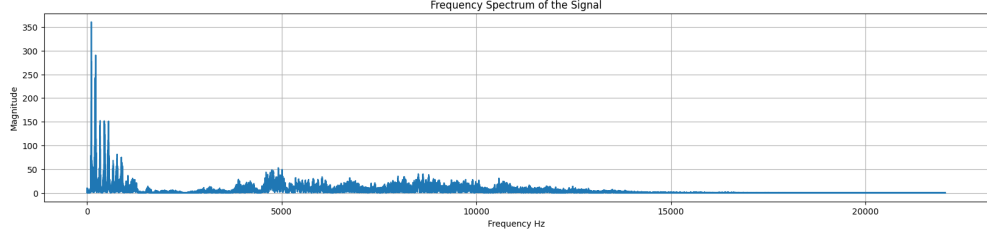The frequency domain of the voice signal, as shown in the figure 2

Fig. 2: Voice signal in frequency domain

2 IIR Filter Design and Application

2.1 Designing the filters

In this section we work on IIR filters of different orders (2, 4, 6) for designing low-pass, high-pass, and band-pass filtering. for instance 3000, 5000, [500,3000] respectively. using appropriate scipy functions for the calculations of the coefficients, and for fhe frequency responses of these filters. plotting them will give us the plots in
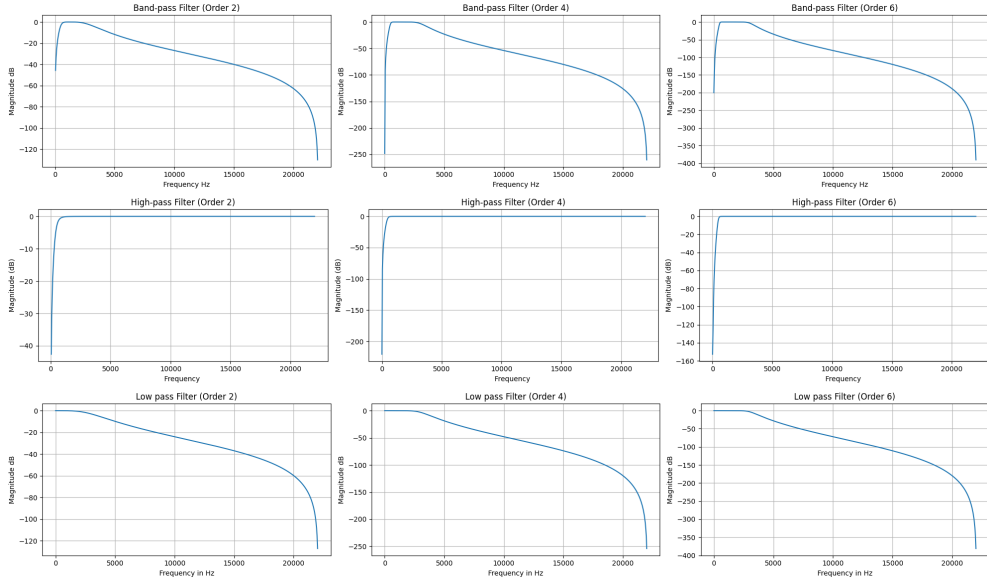

Fig. 3: IIR filters frequency response

The plots are showing sharper transitions with higher orders.

2.2 Filtering the voice signal

we will filter the voice signal with the previous filters, and display the results accordingly. in figure 7

Analysis

Low pass filters with orders 2, 4, and 6 progressively reduce high-frequency components, with higher orders providing sharper cutoffs and smoother signals.

High pass filters of the same orders reduces low frequency components, with higher orders retaining more high frequency content and resulting in less smooth signals.

Bandpass filters takes only a specific frequency range, with higher orders offering sharper cutoffs and better isolation of the unwanted frequencies.

Overall, higher order filters provide sharper cutoffs and somehow smoother signals when we zoom in enough in the images.

3 FIR vs. IIR Filters

In this section we will use FIR filters and compare them to IIR filters. Filtering First we will computer filter coeffecients and designing the FIR filters with different order values same as seen with the IIR filter section 2 The next figure 4 shows the frequency reponse of the FIR filters
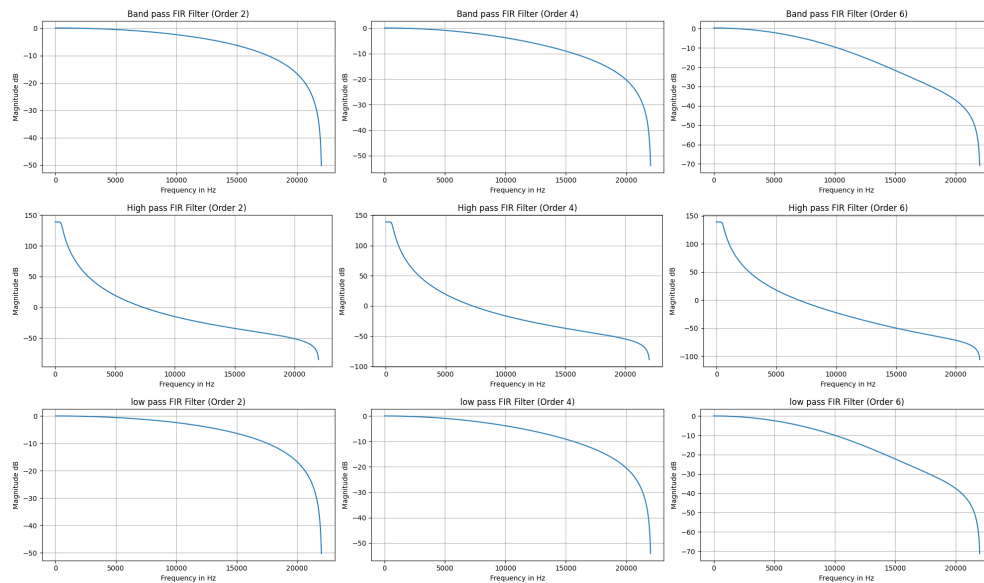

Fig. 4: FIR filters frequency reponse

next we will filter the voice signal with the previous FIR filters and plot the results in both time and frequency domains. see figure 8

3

FIR filters introduce same delay due to same orders used for design. Meaning the signal will typically move the same amount of time in the both filters. but they have very little ripple in the passband and stopband, keeping the signal quality high. They also need more coefficients to make sharp transitions, which can be seen in their smoother and wider transition bands.

On the other hand IIR filters can make sharp transitions making them good fo use. However, they can have more ripple in the passband and stopband, as shown in their sharper but more rippled frequency response plots, we can think of them as when we have artifacts in images. So, FIR filters are better for high quality smoothed signals, while IIR filters are for very stricted applications.

4 Adding Noise and Re-filtering with FIR and IIR Filters

In this section we will add a guassin noise, to have a noisy signal and perform FIR and IIR filtering on it. the time domain of the noisy signal is shown in figure 5 and the freqency domain in figure 6
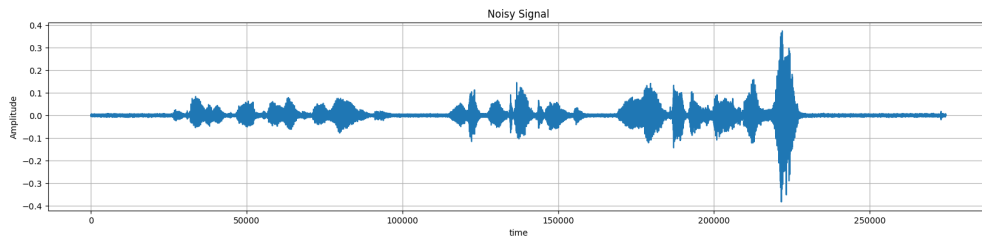

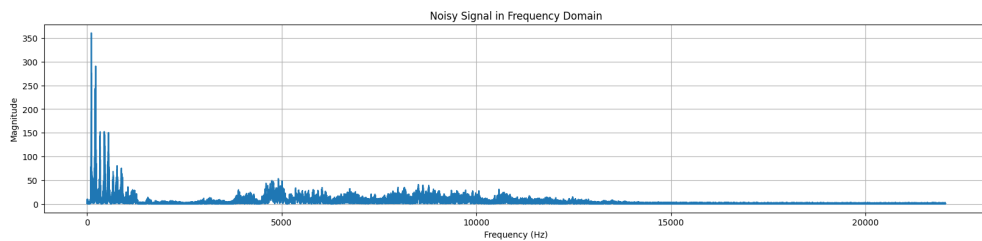**Fig. 5**: Noisy signal in time domain

Fig. 6: Noisy signal in frequency domain

Now as seen in the previous section, we will filter the noisy signal with both IIR and FIR filters with order values ranging from 2,4, 6 and low, high, band passes as follow 3000, 5000, [500,3000]

the results are displayed in both 9 for IIR filters and 10 for FIR filters outputs.

4

FIR filters are slightly better noise reduction due to their minimal ripple. IIR filters achieve effective noise reduction making them more effective in noise reduction and in terms of SNR. Overall, FIR filters are better for preserving voice quality, while IIR filters are more suitable for applications needing very strict filtering.

5 Code and implementation

All of the methods presented in this report, are implemented in a jupyter notebook using python and libraries like numpy, matplotlib, scipy and librosa. **Notebook is accessible in this github repository: LINK**
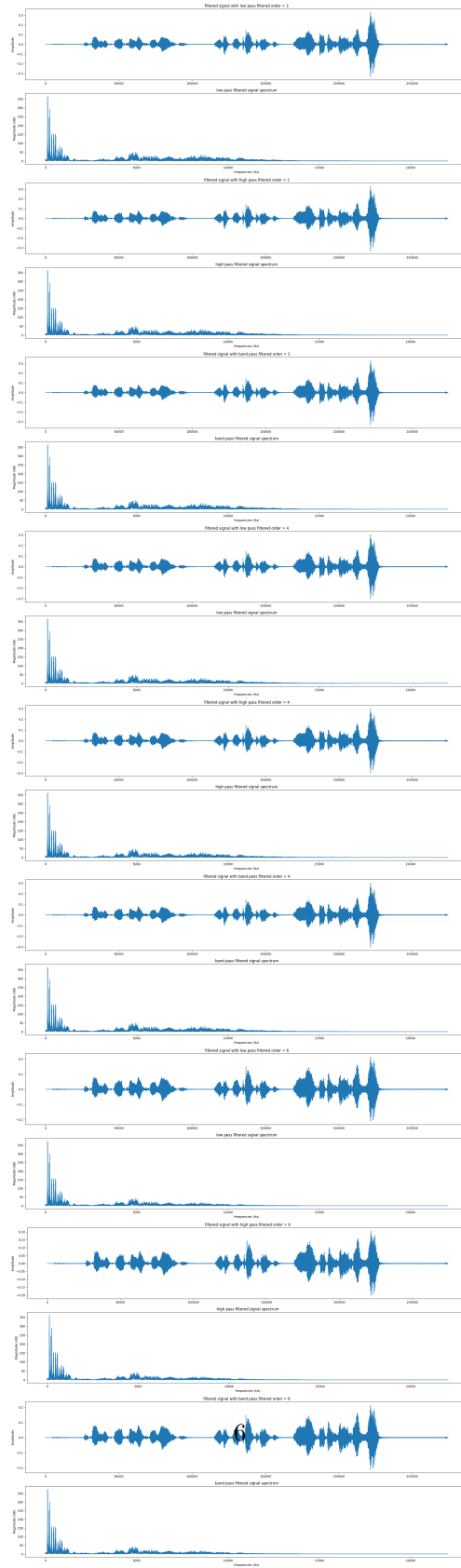
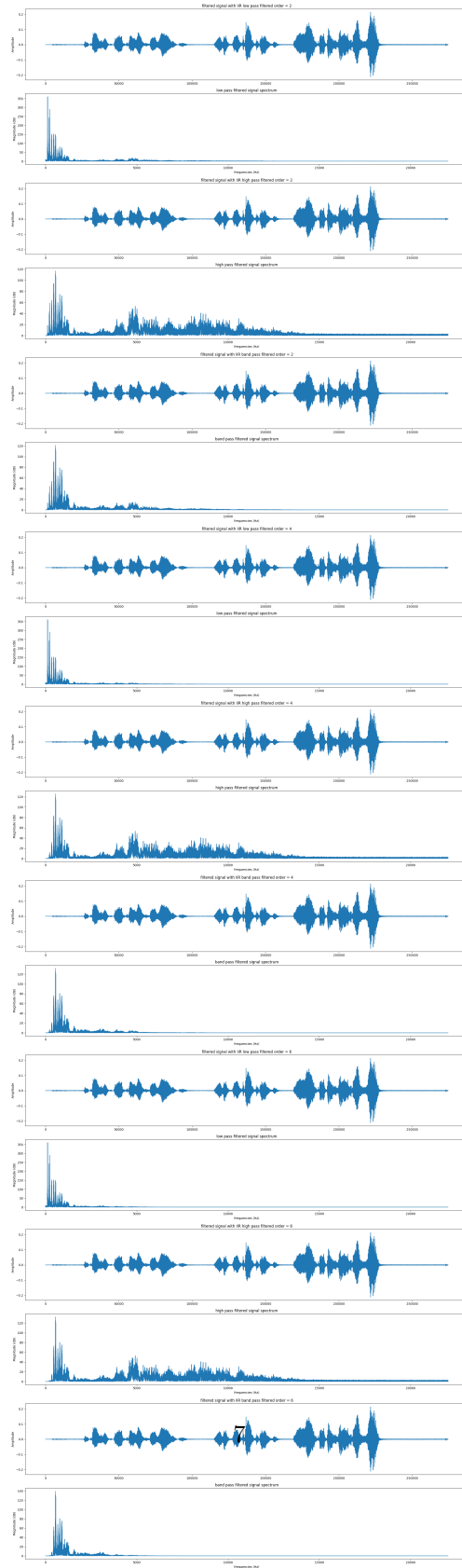**Fig. 8**: voice signal filter with differnt FIR filters

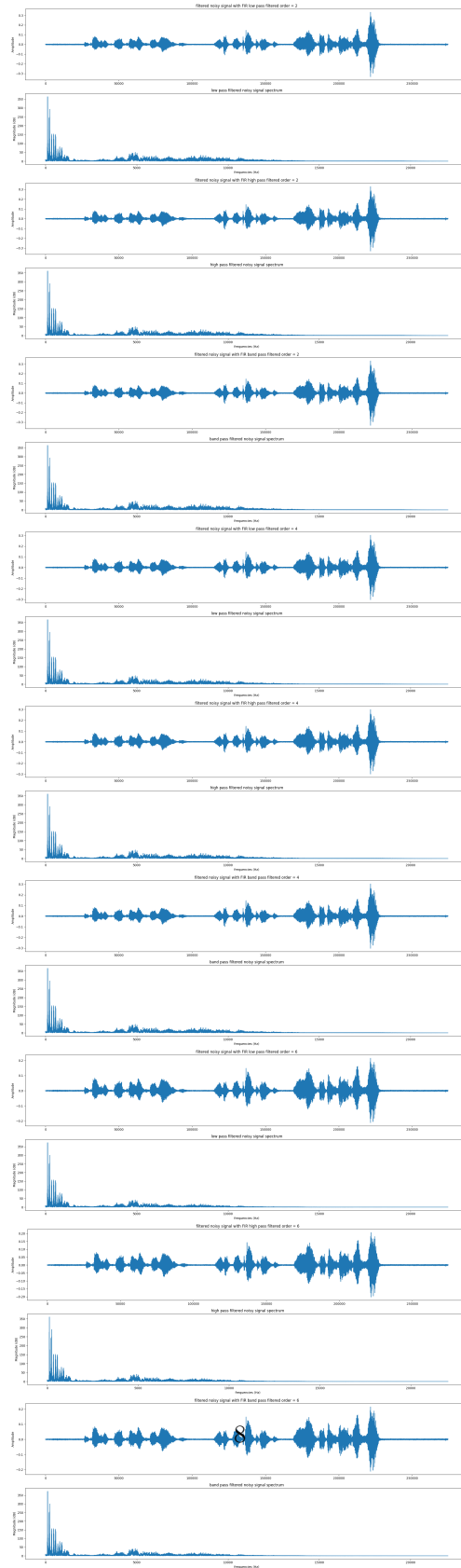**Fig. 9**: Noisy signal filtered with IIR filters

Fig. 10: Noisy signal filtered with FIR filters

References

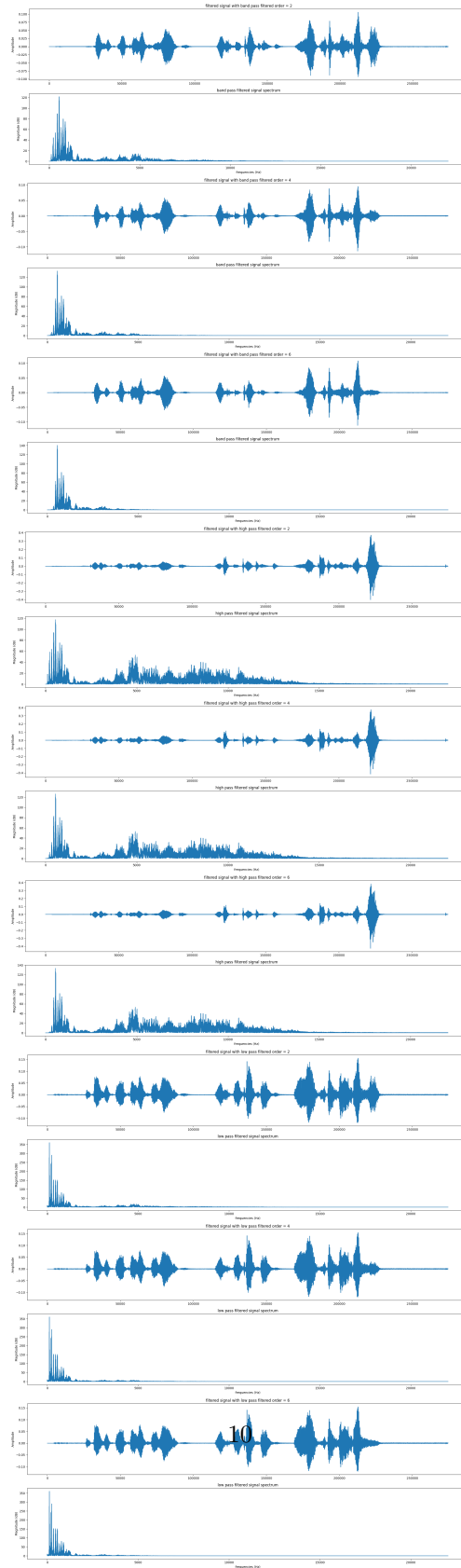[1] Recorder, O.V.: Online Voice Recorder. Last accessed: 29/10/2024 (2024). https://online-voice-recorder.com/fr/

Fig. 7: voice signal filter with differnt IIR filters