ScoreExploration

February 7, 2020

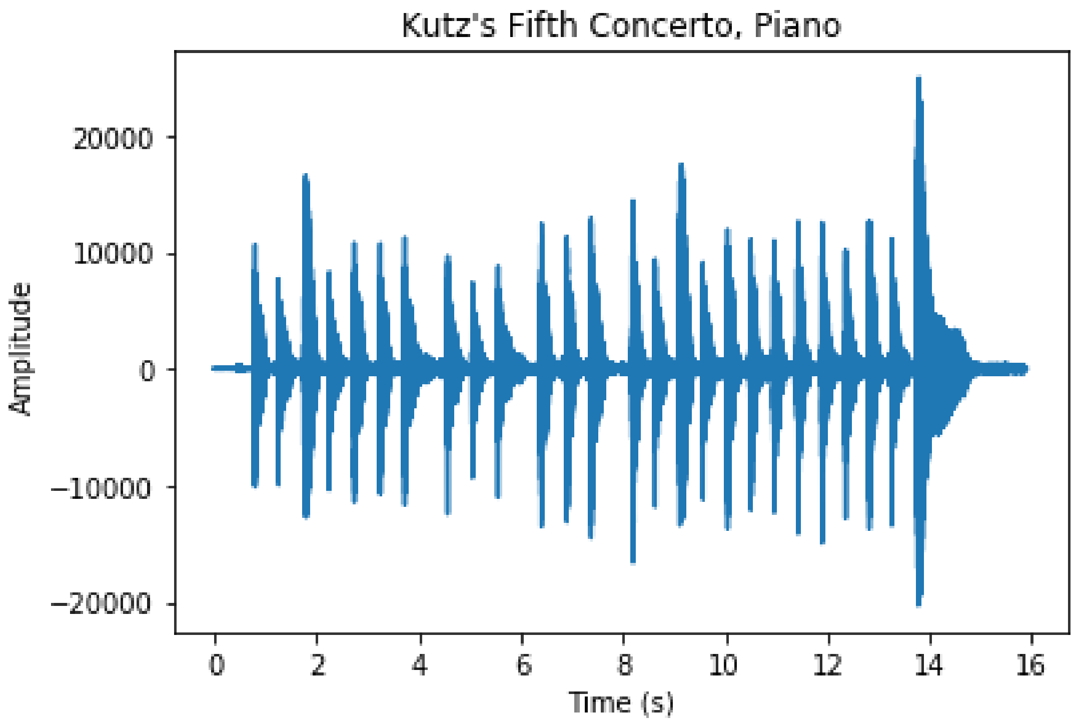
[1]:
```python
%matplotlib inline
import numpy as np
import scipy.signal as sig
from scipy.io import wavfile
import matplotlib.pyplot as plt
import simpleaudio

import fft_funcs
```

[2]:
```python
piano = wavfile.read("music1.wav")
recorder = wavfile.read("music2.wav")
print("Sample rates (Hz):")
print("Piano: {}".format(piano[0]))
print("Recorder: {}".format(piano[0], recorder[0]))
Fs = piano[0]
piano = piano[1]
recorder = recorder[1]

t_piano_max = piano.size*(1.0/Fs)
t_recorder_max = recorder.size*(1.0/Fs)
t_piano = np.linspace(0, t_piano_max, piano.size)
t_recorder = np.linspace(0, t_recorder_max, recorder.size)
```

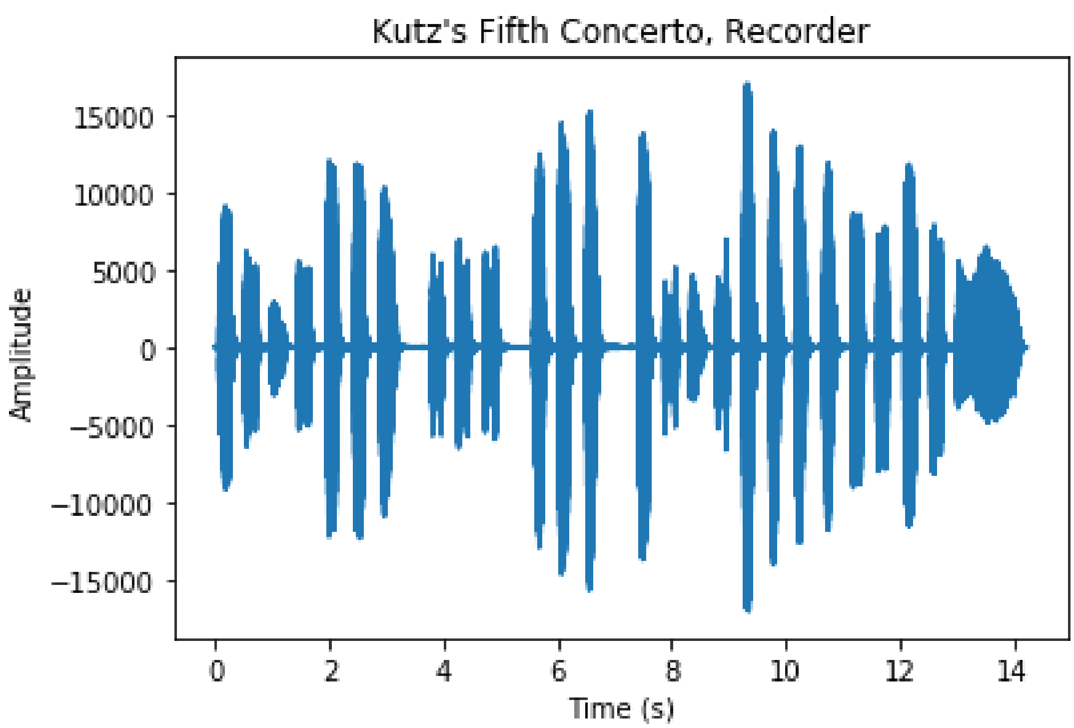
```
Sample rates (Hz):
Piano: 44100
Recorder: 44100
```

[3]:
```python
plt.figure()
plt.title("Kutz's Fifth Concerto, Piano")
plt.xlabel("Time (s)")
plt.ylabel("Amplitude")
plt.plot(t_piano, piano)

plt.figure()
plt.title("Kutz's Fifth Concerto, Recorder")
plt.xlabel("Time (s)")
plt.ylabel("Amplitude")
plt.plot(t_recorder, recorder)
```

```
plt.show()
```

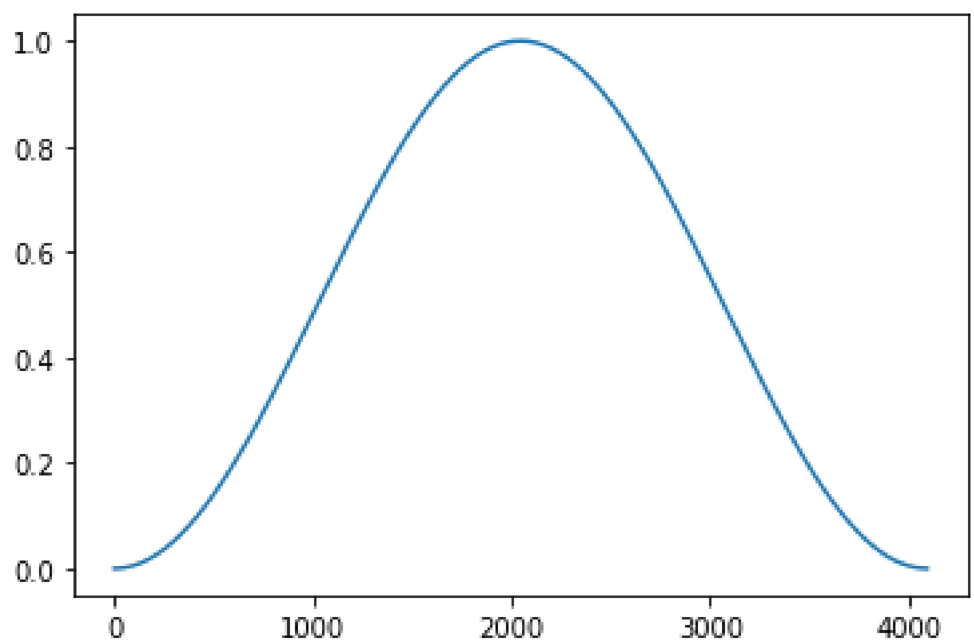


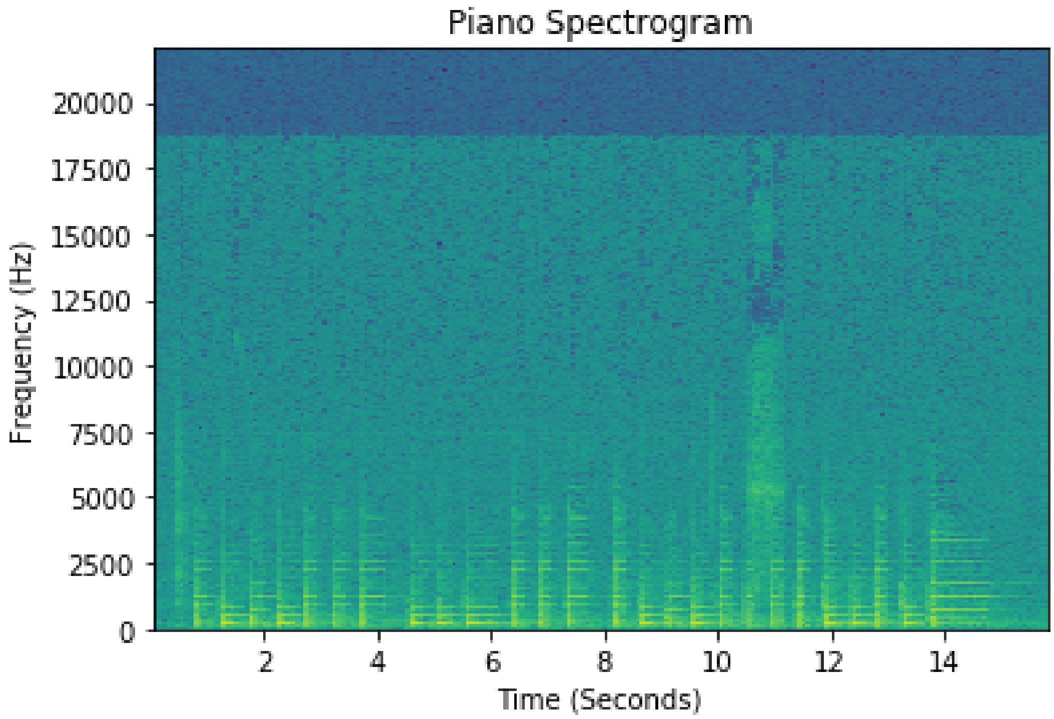
Kutz's Fifth Concerto, Piano
Amplitude
20000
10000
0
−10000
−20000
0
2
4
6
8
10
12
14
16
Time (s)

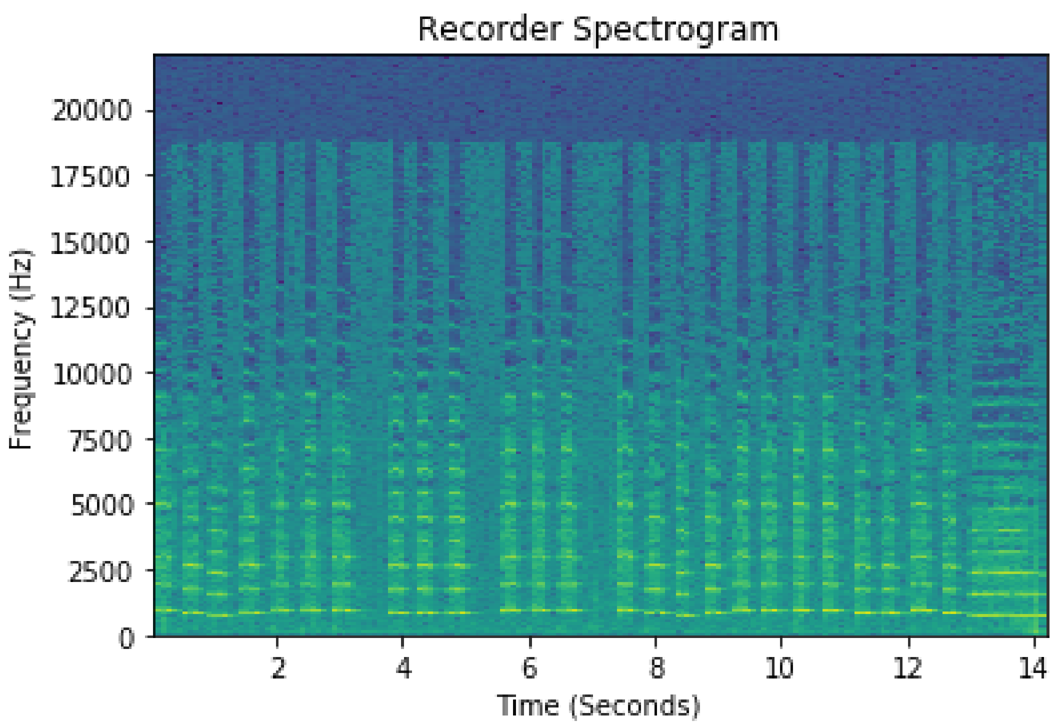


Kutz's Fifth Concerto, Recorder
Amplitude
15000
10000
5000
0
−5000
−10000
−15000
0
2
4
6
8
10
12
14
Time (s)

```
[4]: # This will be coarsely tuned, but we'll start with a totally non-rigorous bet␣
     ↪of 4096 samples
     # (or 4096 samples * (1 second/44100 samples) ~= 9ms)
     nperseg = 4096
     noverlap = nperseg // 8
     # Barring a good spec for considerations like selectivity,
     # side-lobe height, or side lob attenuation, I'm going to pick
     # the Hann(ing) Window for my spectrogram
     window = np.hanning(nperseg)
     plt.figure()
     plt.plot(window)

     title = "Piano Spectrogram"
     fft_funcs.plot_spectrogram(piano, fs=Fs, window=window, normed="log",
                                nperseg=nperseg, noverlap=noverlap, title=title)
     title = "Recorder Spectrogram"
     fft_funcs.plot_spectrogram(recorder, fs=Fs, window=window, normed="log",
                                nperseg=nperseg, noverlap=noverlap,
                                title=title)
```




Piano Spectrogram
20000
17500
15000
12500
10000
7500
5000
2500
0
Frequency (Hz)
2
4
6
8
10
12
14
Time (Seconds)

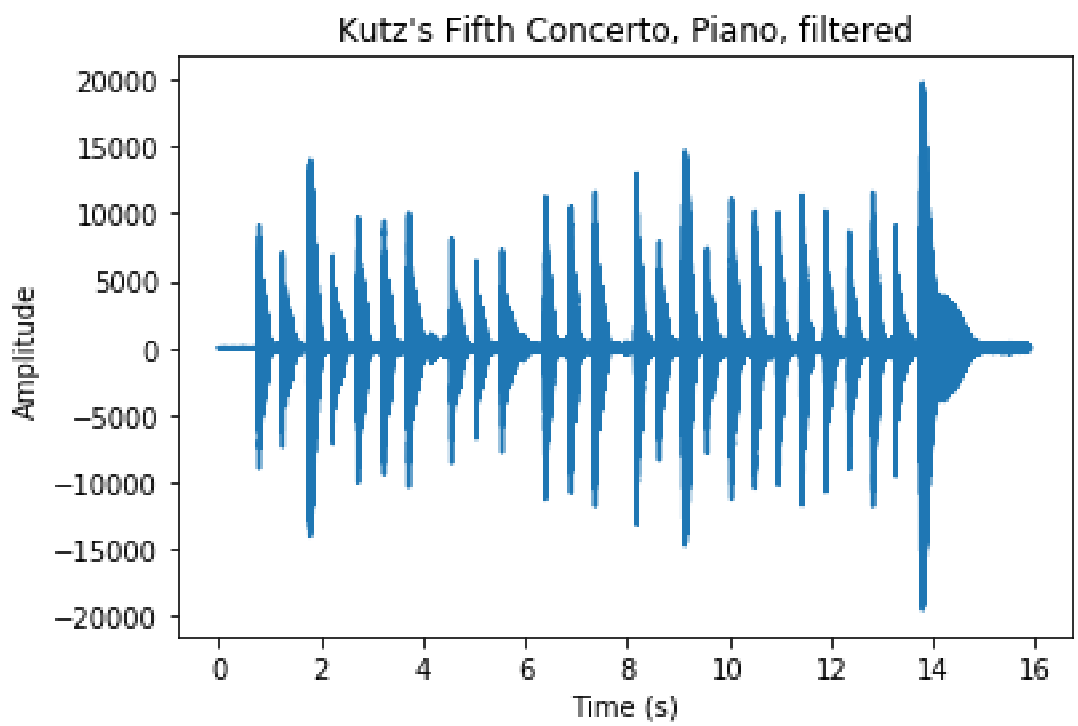

Recorder Spectrogram
20000
17500
15000
12500
10000
7500
5000
2500
0
Frequency (Hz)
2
4
6
8
10
12
14
Time (Seconds)

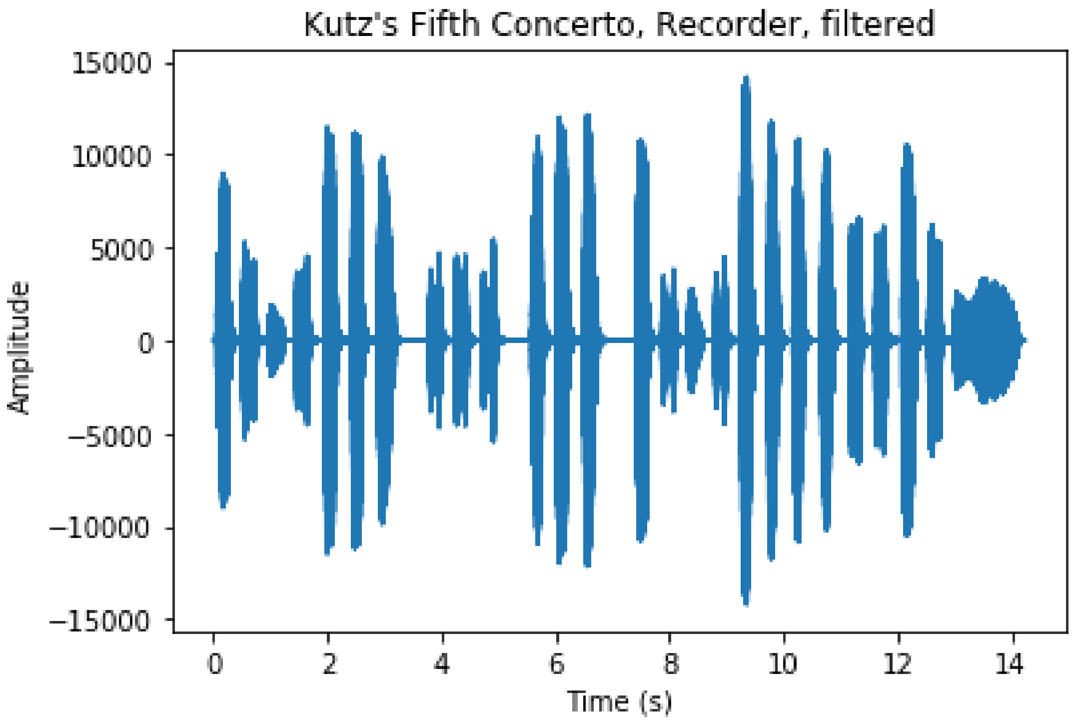
[5]:

```python
# Let's create and apply a filter
# Butterworth: simple, flat passband, bessel is preferred for group delay
# but we're using filtfilt to get linear phase.
# 4th order just cuz
# lowpass to remove overtones. highpass to clean up subharmonic crud
b,a = sig.butter(4, [200, 400], btype="band", analog=False, fs=Fs)
piano_filtered = sig.filtfilt(b, a, piano)
b,a = sig.butter(4, [750, 1250], btype="band", analog=False, fs=Fs)
recorder_filtered = sig.filtfilt(b, a, recorder)
```

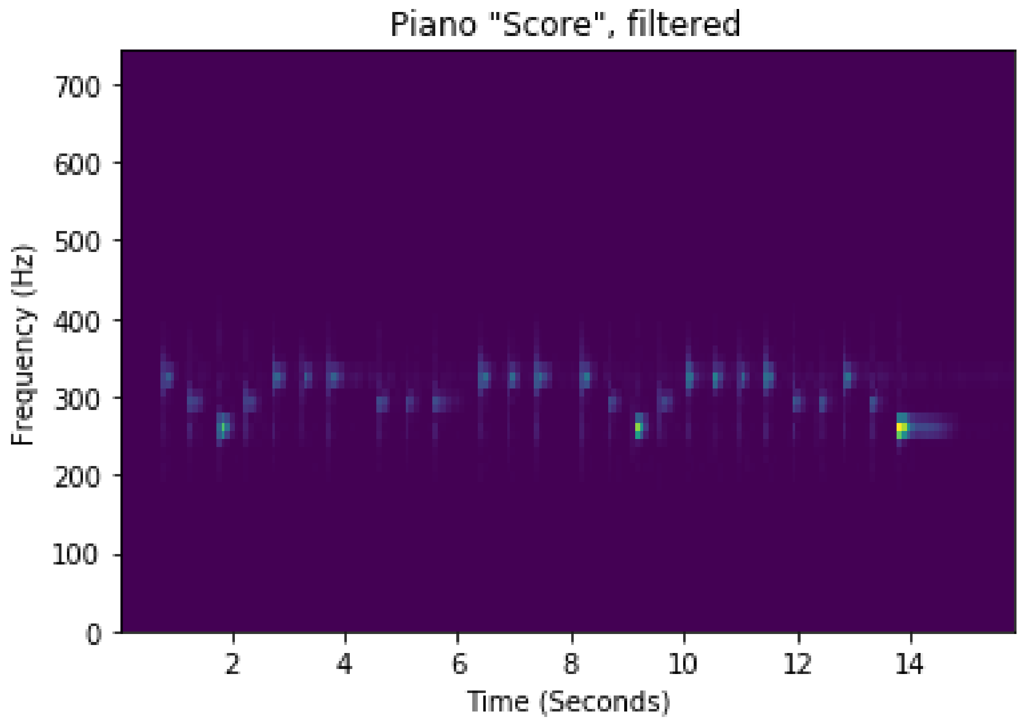
[6]:

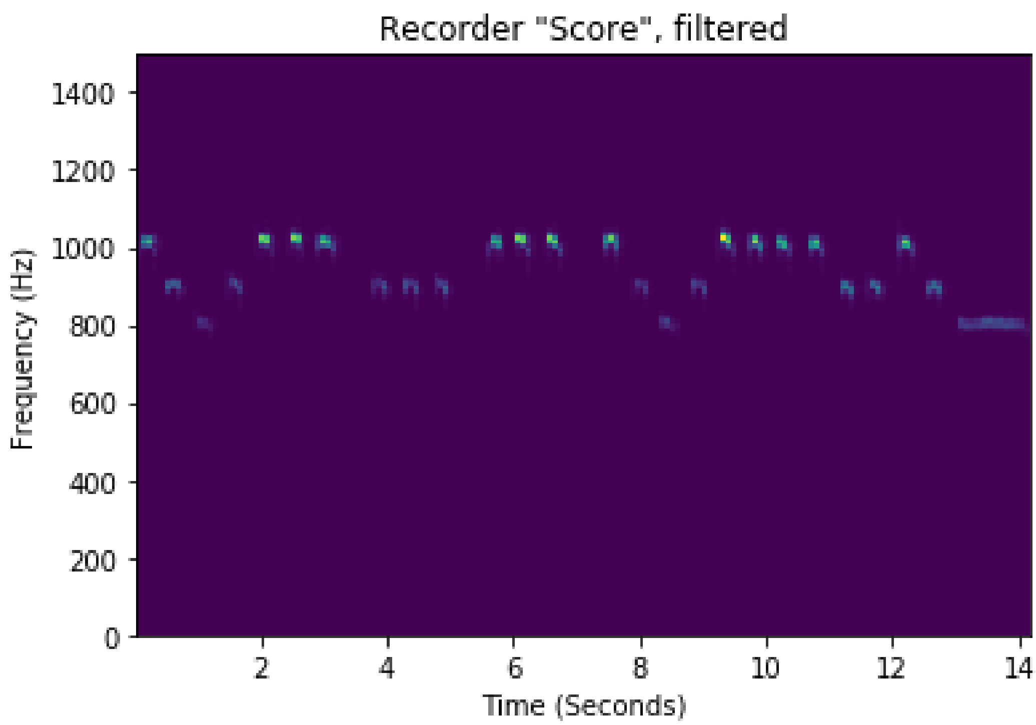
```python
plt.figure()
plt.title("Kutz's Fifth Concerto, Piano, filtered")
plt.xlabel("Time (s)")
plt.ylabel("Amplitude")
plt.plot(t_piano, piano_filtered)

plt.figure()
plt.title("Kutz's Fifth Concerto, Recorder, filtered")
plt.xlabel("Time (s)")
plt.ylabel("Amplitude")
plt.plot(t_recorder, recorder_filtered)

plt.show()
```





[7]:
```
title = "Piano \"Score\", filtered"
fft_funcs.plot_spectrogram(piano_filtered, fs=Fs, window=window, normed="norm",␣
↪maxfreq=750,
                            nperseg=nperseg, noverlap=noverlap, title=title)
title = "Recorder \"Score\", filtered"
fft_funcs.plot_spectrogram(recorder_filtered, fs=Fs, window=window,␣
↪normed="norm", maxfreq=1500,
                            nperseg=nperseg, noverlap=noverlap, title=title)
```

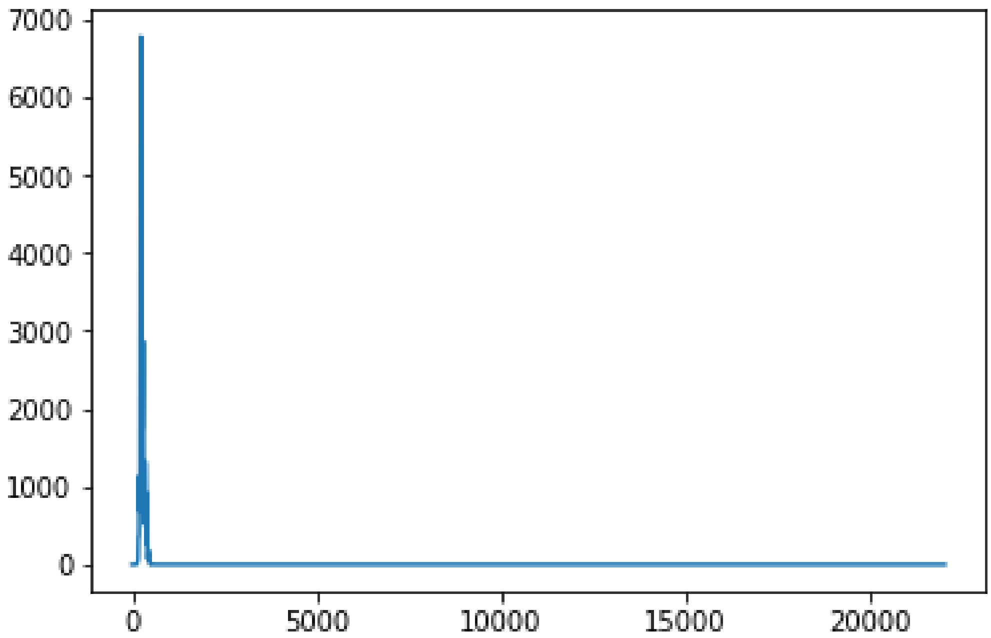

Piano "Score", filtered
Frequency (Hz)
Time (Seconds)


Recorder "Score", filtered
Frequency (Hz)
Time (Seconds)

[8]:
```
# Get a vector of the maximum frequency bin for each slice
freqs_p, t_p, Sxx_p = fft_funcs.spectrogram(piano_filtered, fs=Fs,␣
 ↪window=window, nperseg=nperseg, noverlap=noverlap)
freqs_r, t_r, Sxx_r = fft_funcs.spectrogram(recorder_filtered, fs=Fs,␣
 ↪window=window, nperseg=nperseg, noverlap=noverlap)
```

[9]:
```
print(Sxx_p.shape)
plt.figure()
plt.plot(freqs_p, Sxx_p.T[0])
print(Sxx_r.T[0].argmax())
print(freqs_r[Sxx_r.T[0].argmax()])
```

```
(2049, 195)
93
1001.2939453125
```



[10]:
```
Sxx_p.T[0].shape
```

[10]:
```
(2049,)
```

[ ]: