AMATH 582 Homework 2

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Abstract

The goal of this homework is to reproduce the music score for the guitar in GNR clip and the bass in Floyd clip by Gabor filtering we used in class.

1 Introduction and Overview

There are three questions in this assignment, first of all, we need to filter out overtones and plot the log of the spectrogram which is a visual representation of the spectrum of frequencies of a signal as it varies with time, then we need to isolate the bass in comfortably Numb and figure out how much of the guitar solo can put into it.

1.1 Produce the spectrogram

Follow what we did in class, firstly I decided to use window size five, one and zero point two. Since wider window can give us a better frequency resolution, smaller windows are able to localize the signal in time. I initialized the filter function g(t) being a Gaussian while we are using Gabor transform.

$$g(t-\tau) = \mathrm{e}^{-a(t-\tau)^2}.$$

Set tau equal to a sequence from zero to the length of the clip.

1.2 Isolate the bass in Comfortably Numb

We need to find a filter to filter out the frequency we don't need, I decided to observe the FFT graph of the frequency but trying different range that exclude the high frequencies to obtain the bass.

1.3much of the guitar solo can put together in Comfortably Numb

By plotting the FFT of two clips on top of each other, we can easily obverse the overlaps of frequencies to eyeball the result.

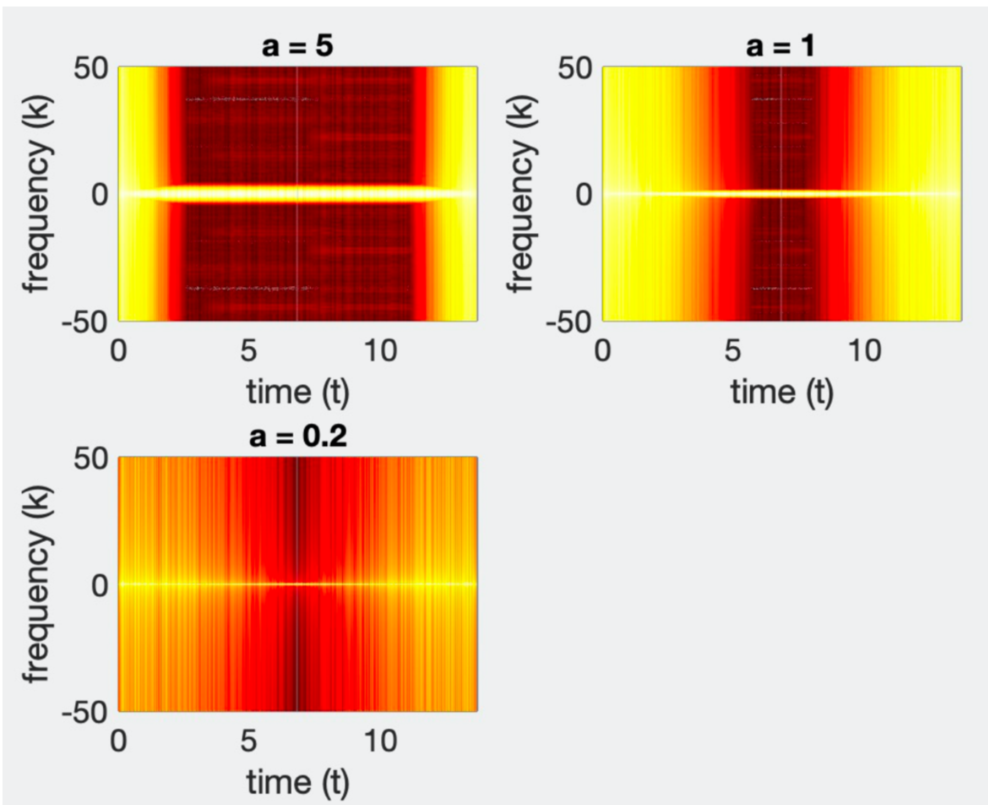
2 Theoretical Background

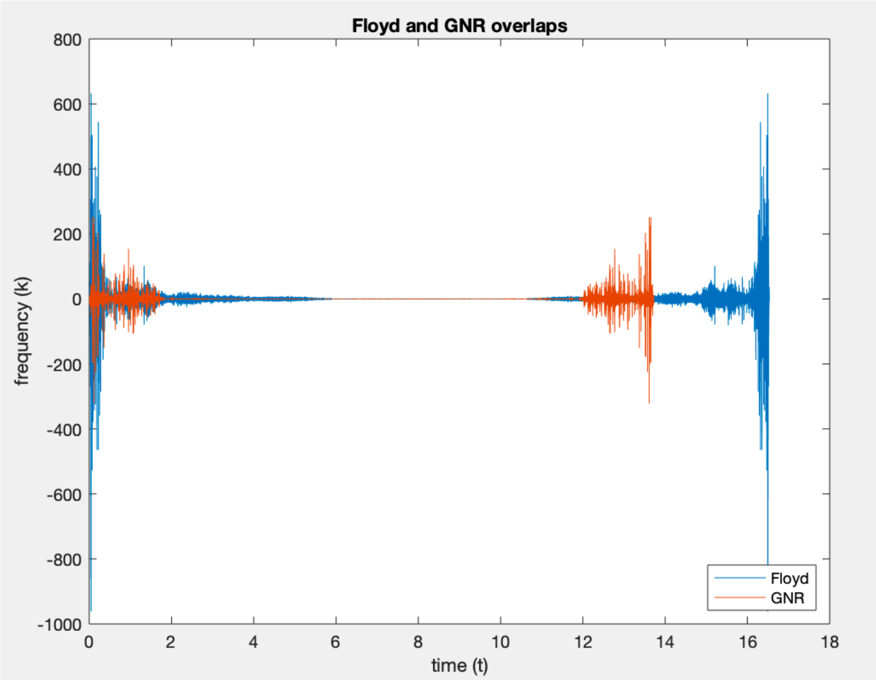
As we learned last week Fourier transform can analyze the frequency of a signal, but FFT losses information in time domain, in order to analyze the frequency without loose information in the time domain, we introduced Gabor transform also named short-time Fourier transform (STFT). We can stack all the Fourier transforms next to each other to form the graph spectrogram. For last two questions, we can plot the FFT graphs of two clips to eyeball the result.

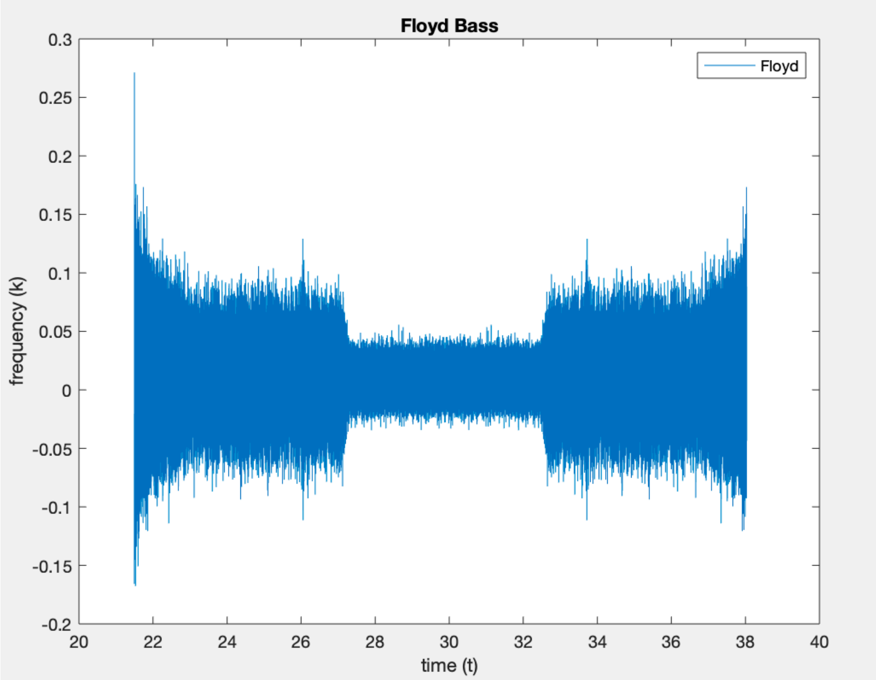
3 Algorithm Implementation and Development

1. Use FFT to localize the overtone
2. Plot the log of the spectrogram
3. Use FFT graph to isolate the bass and observe the overlaps

4 Computational Results







Summary and Conclusions

We successfully plot he log of the spectrogram, isolated the bass and find the overlaps of two clips by analyzing the FFT plot.

Appendix A MATLAB Functions

Y = fftn(X) returns the multidimensional Fourier transform of an N-D array using a fast Fourier transform algorithm. The N-D transform is equivalent to computing the 1-D transform along each dimension of X. The output Y is the same size as X.

[y,Fs] = audioread(filename) reads data from the file named filename, and returns sampled data, y, and a sample rate for that data, Fs.

L = length(X) returns the length of the largest array dimension in X. For vectors, the length is simply the number of elements. For arrays with more dimensions, the length is max(size(X)). The length of an empty array is zero.

plot(X,Y) creates a 2-D line plot of the data in Y versus the corresponding values in X.

Appendix B MATLAB code

```
clear all; clc

%question one
figure(1)
[y, Fs] = audioread('GNR.m4a');
tr_gnr = length(y)/Fs; % record time in seconds
plot((1:length(y))/Fs,y);
xlabel('Time [sec]'); ylabel('Amplitude');
title('Sweet Child O Mine');

p8 = audioplayer(y,Fs);
playblocking(p8);
figure(2)
fy = fft(y);
plot((1:length(fy))/Fs,fy);

figure(3)

L = tr_gnr; n = length(y);
t2 = linspace(0,L,n+1);
t = t2(1:n);
k = (1/L)*[0:n/2-1 -n/2:-1];
ks = fftshift(k);
S=y;
a = [5 1 0.2];
tau = 0:0.01:tr_gnr;
  for jj = 1:length(a)
    Sgt_spec = [];
   for j = 1:length(tau)
       g = exp(-a(jj)*(t - tau(j)).^2);
    Sg = g.*S(j);
    Sgt = fft(Sg);
    Sgt_spec(:,j) = fftshift(abs(Sgt));
   end
   subplot(2,2,jj)
```

```
   pcolor(tau,ks,log(Sgt_spec)+1)
   shading interp
   set(gca,'ylim',[-50 50],'Fontsize',16)
   colormap(hot)
   %colorbar
   xlabel('time (t)'), ylabel('frequency (k)')
   title(['a = ',num2str(a(jj))],'Fontsize',16)
  end



%question 2
 [y_1, Fs_1] = audioread('Floyd.m4a');
 tr_gnr = length(y_1)/Fs_1; % record time in seconds
 figure(1)
 fy_1 = fft(y_1);
 t = (1:length(fy_1))/Fs_1;
 t = t(1,947950:1677416);
 fy_1 = fy_1(947950:1677416,1);
 plot(t,fy_1);
 legend("Floyd Bass")

%question3
[y_1, Fs_1] = audioread('Floyd.m4a');
tr_gnr = length(y_1)/Fs_1; % record time in seconds

[y_2, Fs_2] = audioread('GNR.m4a');
tr_gnr = length(y_2)/Fs_2; % record time in seconds


figure(1)
fy_1 = fft(y_1);
fy_2 = fft(y_2);
plot((1:length(fy_1))/Fs_1,fy_1);
hold on
plot((1:length(fy_2))/Fs_2,y_2);
xlabel('time (t)'), ylabel('frequency (k)')
legend('Floyd', 'GNR', 'Location', 'SouthEast')
title('Floyd and GNR overlaps')

 figure(2)
fy_1_short = y_1(947950:1677416,1);
fy_1_short = fft(fy_1_short);
fy_2 = fft(y_2);
fy_2_short = fy_2;
plot((1:length(fy_1_short))/Fs_1,fy_1_short);
hold on
plot((1:length(fy_2_short))/Fs_2,fy_2_short);
xlabel('time (t)'), ylabel('frequency (k)')
legend('Floyd', 'GNR', 'Location', 'SouthEast')
title('Floyd and GNR overlaps')
```