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## Table of Contents

.....	1
read audio .....	1
downsample and FFT .....	2
Plot max of each window .....	2
classify and count pitches .....	3

```
clc
clear all
close all
```

## read audio

```
[Y,fs] = audioread('yankee.m4a');
dt = 1/fs;
t = (0:length(Y)-1)/fs;
f = linspace(-fs/2,fs/2,fs);
[r, c] = size(Y);

player = audioplayer(Y(:,1),fs);
ch1 = Y(:,1);
ch2 = zeros(r, 1);
if c == 2
    ch2 = Y(:,2);
end
song = 0.5*(ch1 + ch2);
FFT = abs(fft(song,fs));

window_dur = 31000;
rem = mod(r, window_dur);

song = [song; zeros(window_dur - rem, 1)];
dur = length(song);
n_windows = dur/window_dur;
windowed = zeros(window_dur, n_windows);
df = fs/(window_dur);
FFTs = zeros(window_dur, n_windows);
hps = [];
>window = ones(window_dur, 1);
>window = hamming(window_dur);
>Windowing

for i=1:n_windows-1
    k = i.*window_dur - (window_dur-1);
    j = k+window_dur - 1;
    windowed(:,i) = window.*song(k:j);
end
```

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## downsample and FFT

```
for i=1:n_windows
    FFTs(:,i) = abs(fft(windowed(:,i)));
    hps1 = downsample(FFTs(:, i),1);
    hps2 = downsample(FFTs(:, i),2);
    hps3 = downsample(FFTs(:, i),3);
    hps4 = downsample(FFTs(:, i),4);
    hps5 = downsample(FFTs(:, i),5);

    for j=1:length(hps5)
        product = abs(hps1(j)) * abs(hps2(j)) * abs(hps3(j)) *
abs(hps4(j)) * abs(hps5(j));
        hps(j,i) = product;
    end
    [val, ind] = max(FFTs(:, i));
    fft_max(i) = val;
    fft_freq(i) = ind*df;
end
```

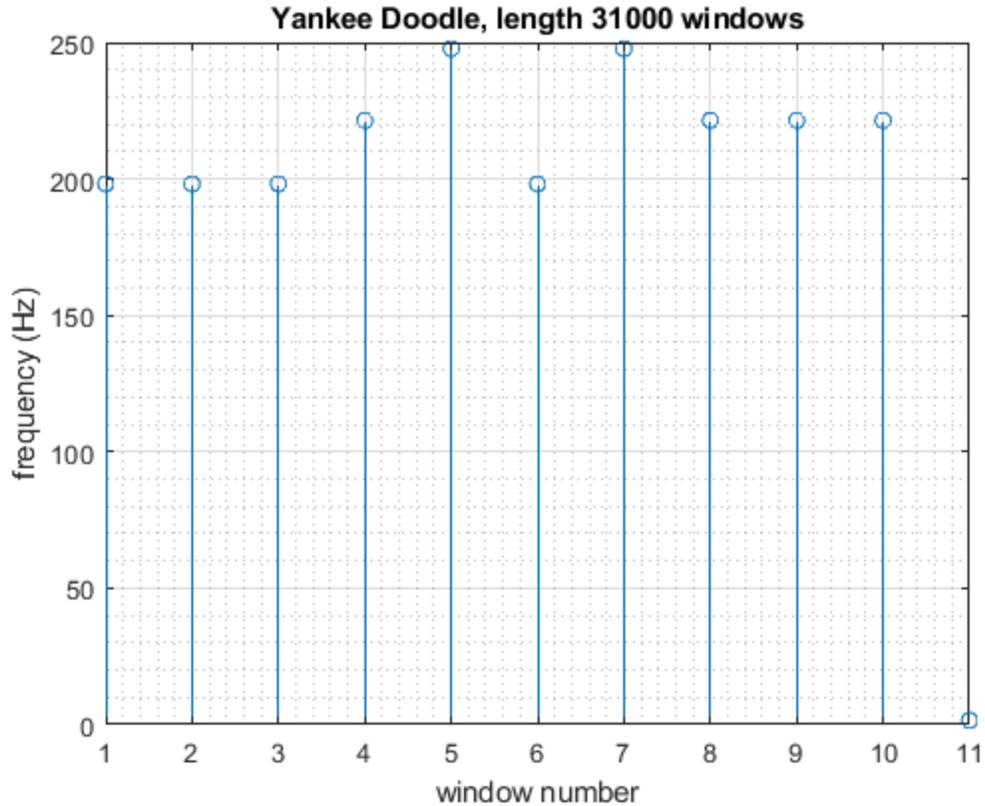
## Plot max of each window

```
max_hps = zeros(1,n_windows);
max_index_hps = zeros(1,n_windows);

for i=1:n_windows
    [max_hps_value,index_value] = max(hps(:,i));
    max_hps(1,i) = max_hps_value;
    max_index_hps(1,i) = index_value.*df;
end

x = 1:n_windows;
figure()
stem(x, max_index_hps);
hold on
title('Yankee Doodle, length 31000 windows')
xlabel('window number')
ylabel('frequency (Hz)')
grid on
grid minor

pitch = {};
pitch_counts = zeros(1, 12);
```



## classify and count pitches

```

for i=1:n_windows
    if ((max_index_hps(1,i) >= 15.835) && (max_index_hps(1,i) <
16.835))...
        || ((max_index_hps(1,i) >= 31.785) && (max_index_hps(1,i) <
33.675))...
        || ((max_index_hps(1,i) >= 63.575) && (max_index_hps(1,i) <
67.355))...
        || ((max_index_hps(1,i) >= 127.14) && (max_index_hps(1,i) <
134.7))...
        || ((max_index_hps(1,i) >= 254.285) && (max_index_hps(1,i) <
269.405))...
        || ((max_index_hps(1,i) >= 508.565) && (max_index_hps(1,i) <
538.81))...
        || ((max_index_hps(1,i) >= 1017.137) && (max_index_hps(1,i) <
1077.615)))
        pitch{i} = 'C';
        pitch_counts(1) = pitch_counts(1) + 1;
    elseif ((max_index_hps(1,i) >= 16.835) && (max_index_hps(1,i) <
17.835))...
        || ((max_index_hps(1,i) >= 33.675) && (max_index_hps(1,i) <
35.68))...
        || ((max_index_hps(1,i) >= 67.355) && (max_index_hps(1,i) <
71.36))...

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    || ((max_index_hps(1,i) >= 134.7) && (max_index_hps(1,i) <
142.71))...
    || ((max_index_hps(1,i) >= 269.405) && (max_index_hps(1,i) <
285.42))...
    || ((max_index_hps(1,i) >= 538.81) && (max_index_hps(1,i) <
570.85)))
        pitch{i} = 'C#';
        pitch_counts(2) = pitch_counts(2) + 1;
    elseif (((max_index_hps(1,i) >= 17.835) && (max_index_hps(1,i) <
18.9))...
    || ((max_index_hps(1,i) >= 35.68) && (max_index_hps(1,i) <
37.8))...
    || ((max_index_hps(1,i) >= 71.36) && (max_index_hps(1,i) <
75.6))...
    || ((max_index_hps(1,i) >= 142.71) && (max_index_hps(1,i) <
151.195))...
    || ((max_index_hps(1,i) >= 285.42) && (max_index_hps(1,i) <
302.395))...
    || ((max_index_hps(1,i) >= 570.85) && (max_index_hps(1,i) <
604.79))...
        pitch{i} = 'D';
        pitch_counts(3) = pitch_counts(3) + 1;
    elseif (((max_index_hps(1,i) >= 18.9) && (max_index_hps(1,i) <
20.025))...
    || ((max_index_hps(1,i) >= 37.8) && (max_index_hps(1,i) <
40.045))...
    || ((max_index_hps(1,i) >= 75.6) && (max_index_hps(1,i) <
80.095))...
    || ((max_index_hps(1,i) >= 151.195) && (max_index_hps(1,i) <
160.185))...
    || ((max_index_hps(1,i) >= 302.395) && (max_index_hps(1,i) <
320.38))...
    || ((max_index_hps(1,i) >= 604.79) && (max_index_hps(1,i) <
640.75)))
        pitch{i} = 'D#';
        pitch_counts(4) = pitch_counts(4) + 1;
    elseif (((max_index_hps(1,i) >= 20.025) && (max_index_hps(1,i) <
21.215))...
    || ((max_index_hps(1,i) >= 40.045) && (max_index_hps(1,i) <
42.425))...
    || ((max_index_hps(1,i) >= 80.095) && (max_index_hps(1,i) <
84.86))...
    || ((max_index_hps(1,i) >= 160.185) && (max_index_hps(1,i) <
169.71))...
    || ((max_index_hps(1,i) >= 320.38) && (max_index_hps(1,i) <
339.43))...
    || ((max_index_hps(1,i) >= 640.75) && (max_index_hps(1,i) <
678.855)))
        pitch{i} = 'E';
        pitch_counts(5) = pitch_counts(5) + 1;
    elseif (((max_index_hps(1,i) >= 21.215) && (max_index_hps(1,i) <
22.475))...
    || ((max_index_hps(1,i) >= 42.425) && (max_index_hps(1,i) <
44.95))...

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    || ((max_index_hps(1,i) >= 84.86) && (max_index_hps(1,i) <
89.905))...
    || ((max_index_hps(1,i) >= 169.71) && (max_index_hps(1,i) <
179.805))...
    || ((max_index_hps(1,i) >= 339.43) && (max_index_hps(1,i) <
359.61))...
    || ((max_index_hps(1,i) >= 678.855) && (max_index_hps(1,i) <
719.225))
        pitch{i} = 'F';
        pitch_counts(6) = pitch_counts(6) + 1;
    elseif ((max_index_hps(1,i) >= 22.475) && (max_index_hps(1,i) <
23.81))...
    || ((max_index_hps(1,i) >= 44.95) && (max_index_hps(1,i) <
47.625))...
    || ((max_index_hps(1,i) >= 89.905) && (max_index_hps(1,i) <
95.25))...
    || ((max_index_hps(1,i) >= 179.805) && (max_index_hps(1,i) <
190.5))...
    || ((max_index_hps(1,i) >= 359.61) && (max_index_hps(1,i) <
380.995))...
    || ((max_index_hps(1,i) >= 719.225) && (max_index_hps(1,i) <
761.99))
        pitch{i} = 'F#';
        pitch_counts(7) = pitch_counts(7) + 1;
    elseif ((max_index_hps(1,i) >= 23.81) && (max_index_hps(1,i) <
25.23))...
    || ((max_index_hps(1,i) >= 47.625) && (max_index_hps(1,i) <
50.455))...
    || ((max_index_hps(1,i) >= 95.25) && (max_index_hps(1,i) <
100.915))...
    || ((max_index_hps(1,i) >= 190.5) && (max_index_hps(1,i) <
201.825))...
    || ((max_index_hps(1,i) >= 380.995) && (max_index_hps(1,i) <
403.65))...
    || ((max_index_hps(1,i) >= 761.99) && (max_index_hps(1,i) <
807.3))
        pitch{i}= 'G';
        pitch_counts(8) = pitch_counts(8) + 1;
    elseif ((max_index_hps(1,i) >= 25.23) && (max_index_hps(1,i) <
26.73))...
    || ((max_index_hps(1,i) >= 50.455) && (max_index_hps(1,i) <
53.455))...
    || ((max_index_hps(1,i) >= 100.915) && (max_index_hps(1,i) <
106.915))...
    || ((max_index_hps(1,i) >= 201.825) && (max_index_hps(1,i) <
213.825))...
    || ((max_index_hps(1,i) >= 403.65) && (max_index_hps(1,i) <
427.65))...
    || ((max_index_hps(1,i) >= 807.3) && (max_index_hps(1,i) <
855.305))
        pitch{i} = 'G#';
        pitch_counts(9) = pitch_counts(9) + 1;
    elseif ((max_index_hps(1,i) >= 26.73) && (max_index_hps(1,i) <
28.32))...

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        || ((max_index_hps(1,i) >= 53.455) && (max_index_hps(1,i) <
56.635))...
        || ((max_index_hps(1,i) >= 106.915) && (max_index_hps(1,i) <
113.27))...
        || ((max_index_hps(1,i) >= 213.825) && (max_index_hps(1,i) <
226.54))...
        || ((max_index_hps(1,i) >= 427.65) && (max_index_hps(1,i) <
453.08))...
        || ((max_index_hps(1,i) >= 855.305) && (max_index_hps(1,i) <
906.165)))
        pitch{i} = 'A';
        pitch_counts(10) = pitch_counts(10) + 1;
    elseif ((max_index_hps(1,i) >= 28.32) && (max_index_hps(1,i) <
30.005))...
        || ((max_index_hps(1,i) >= 56.635) && (max_index_hps(1,i) <
60.005))...
        || ((max_index_hps(1,i) >= 113.27) && (max_index_hps(1,i) <
120.005))...
        || ((max_index_hps(1,i) >= 226.54) && (max_index_hps(1,i) <
240.01))...
        || ((max_index_hps(1,i) >= 453.08) && (max_index_hps(1,i) <
480.02))...
        || ((max_index_hps(1,i) >= 906.165) && (max_index_hps(1,i) <
960.05)))
        pitch{i} = 'A#';
        pitch_counts(11) = pitch_counts(11) + 1;
    elseif ((max_index_hps(1,i) >= 30.005) && (max_index_hps(1,i) <
31.785))...
        || ((max_index_hps(1,i) >= 60.005) && (max_index_hps(1,i) <
63.575))...
        || ((max_index_hps(1,i) >= 120.005) && (max_index_hps(1,i) <
127.14))...
        || ((max_index_hps(1,i) >= 240.01) && (max_index_hps(1,i) <
254.285))...
        || ((max_index_hps(1,i) >= 480.02) && (max_index_hps(1,i) <
508.565))...
        || ((max_index_hps(1,i) >= 960.05) && (max_index_hps(1,i) <
1017.135)))
        pitch{i} = 'B';
        pitch_counts(12) = pitch_counts(12) + 1;
    else
    end
end
end

```

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