Sistema de filtragem

```
clearvars
```

Recolha de dados

```
% filename = "domingues3.csv";
% data_table = readtable(filename,"VariableNamingRule","preserve");
% data_set_z = table2array(data_table(:,"z_accel"));
% data_time = table2array(data_table(:,"Hours:Minutes:Seconds.Milliseconds"));
% data_time = seconds(data_time); data_time = data_time - data_time(1);

bitalino_Fs = 100;
data_table = readtable("domingues_coxis_01.txt");
data_set_z = table2array(data_table(:,"Var6"));
data_time = linspace(0,length(data_set_z)/bitalino_Fs,length(data_set_z))';
```

Frequência

```
L = length(data_time);

Fs = mean(1./diff(data_time));
disp("Sampling rate: " + Fs + "Hz")
```

```
Sampling rate: 99.9904Hz
```

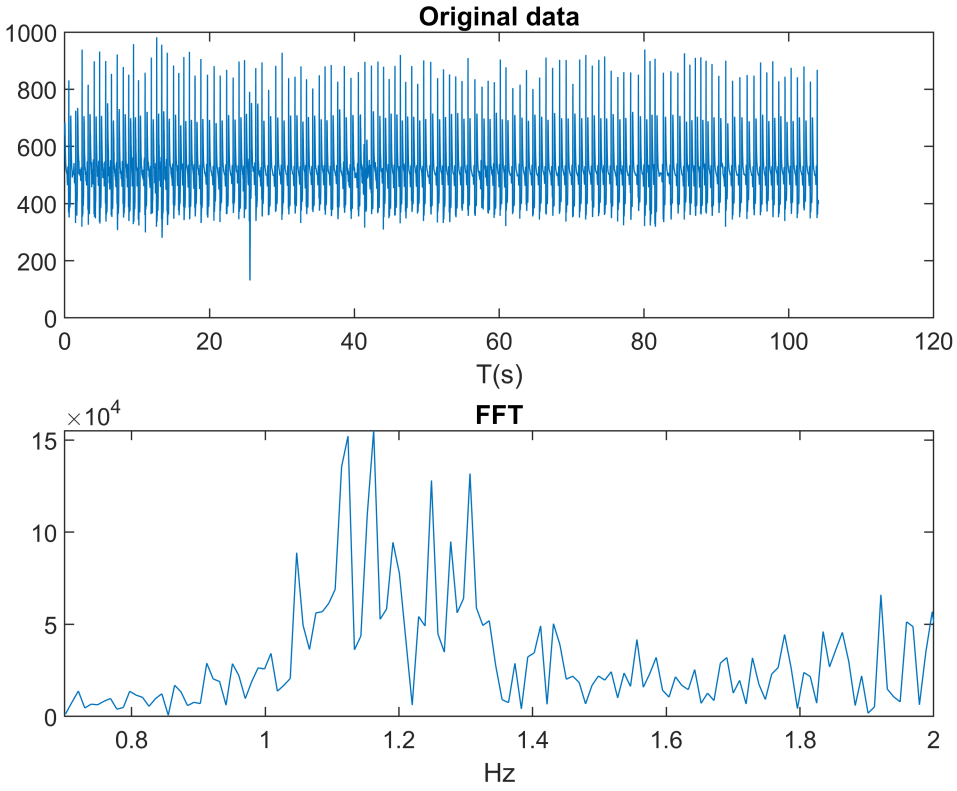
```

f = Fs*(0:(L/2))/L;
```

Z_DATA

```
fft_z = fft(data_set_z - mean(data_set_z));
```

Plots

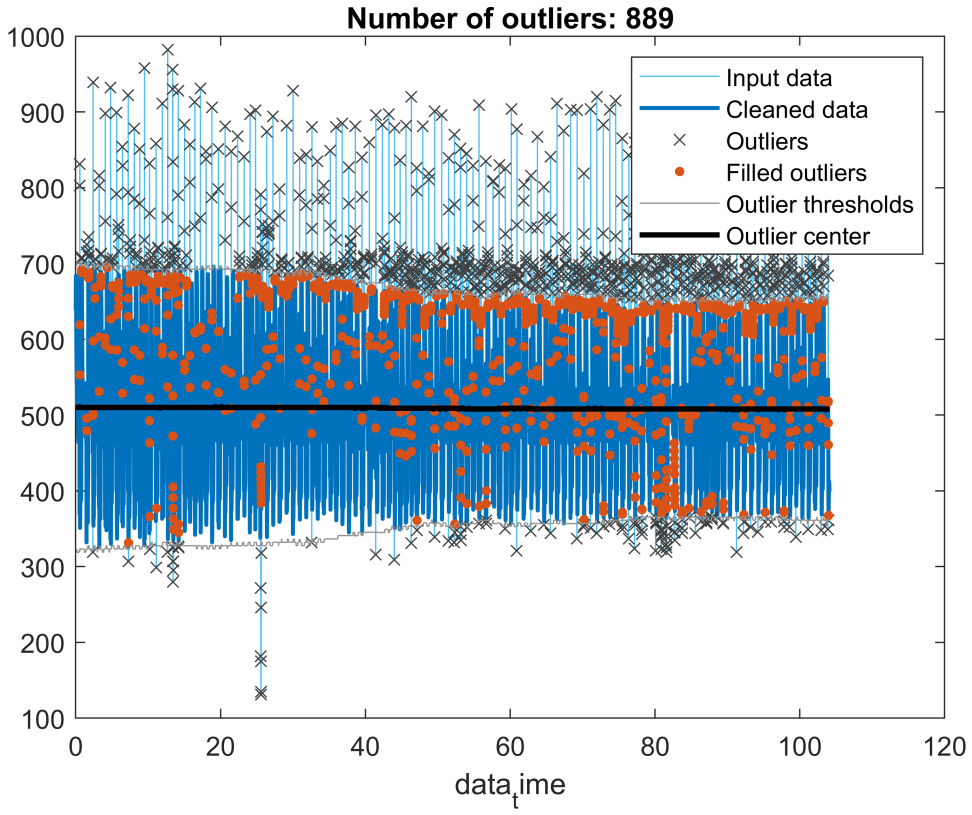
```
figure,
subplot(211),plot(data_time, data_set_z)
title("Original data"),xlabel("T(s)")
subplot(212),plot(f, abs(fft_z(1:numel(f)))*2)
title("FFT"),xlim([0.7, 2]),xlabel("Hz")
```



Remove outliers

```
% Fill outliers
[outliers,outlierIndices,thresholdLow,thresholdHigh,center] = ...
    filloutliers(data_set_z,"linear","movmedian",60,"SamplePoints",data_time);

% Display results
clf
plot(data_time,data_set_z,"Color",[77 190 238]/255,...
    "DisplayName","Input data")
hold on
plot(data_time,outliers,"Color",[0 114 189]/255,"LineWidth",1.5,...
    "DisplayName","Cleaned data")

% Plot outliers
plot(data_time(outlierIndices),data_set_z(outlierIndices),"x",...
    "Color",[64 64 64]/255,"DisplayName","Outliers")
title("Number of outliers: " + nnz(outlierIndices))

% Plot filled outliers
plot(data_time(outlierIndices),outliers(outlierIndices),".","MarkerSize",12,...
    "Color",[217 83 25]/255,"DisplayName","Filled outliers")

% Plot outlier thresholds
plot([data_time(:); missing; data_time(:)],...
    [thresholdHigh(:); missing; thresholdLow(:)],"Color",[145 145 145]/255,...
    "DisplayName","Outlier thresholds")
```

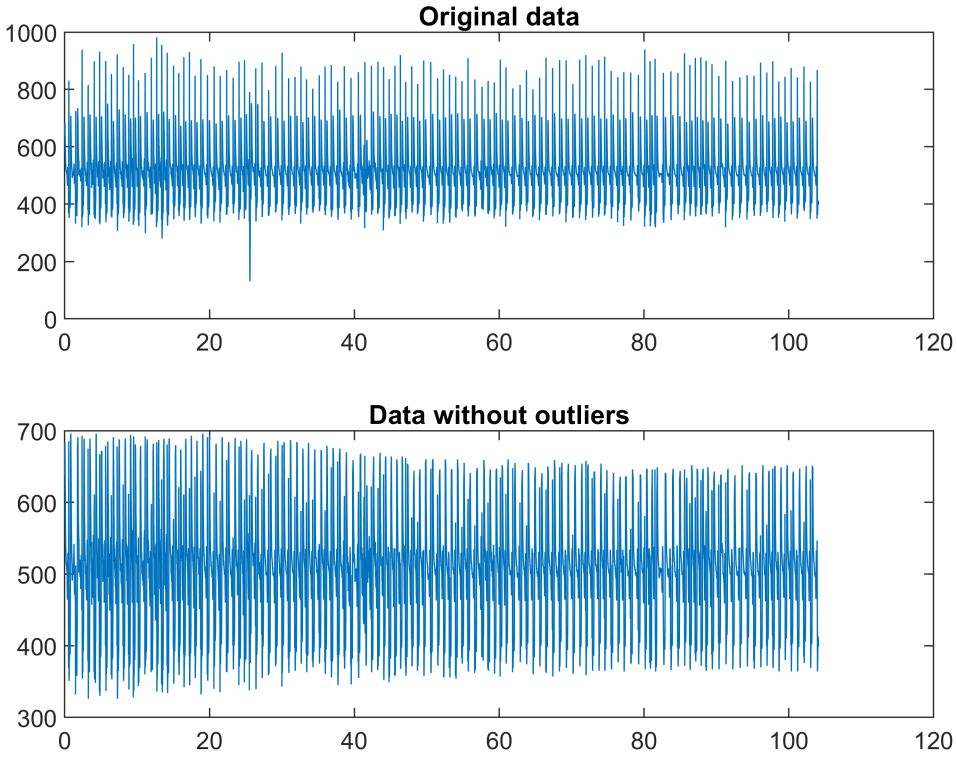
```
% Plot outlier center
plot(data_time,center,"k","LineWidth",2,"DisplayName","Outlier center")

hold off
legend
xlabel("data_time")
```



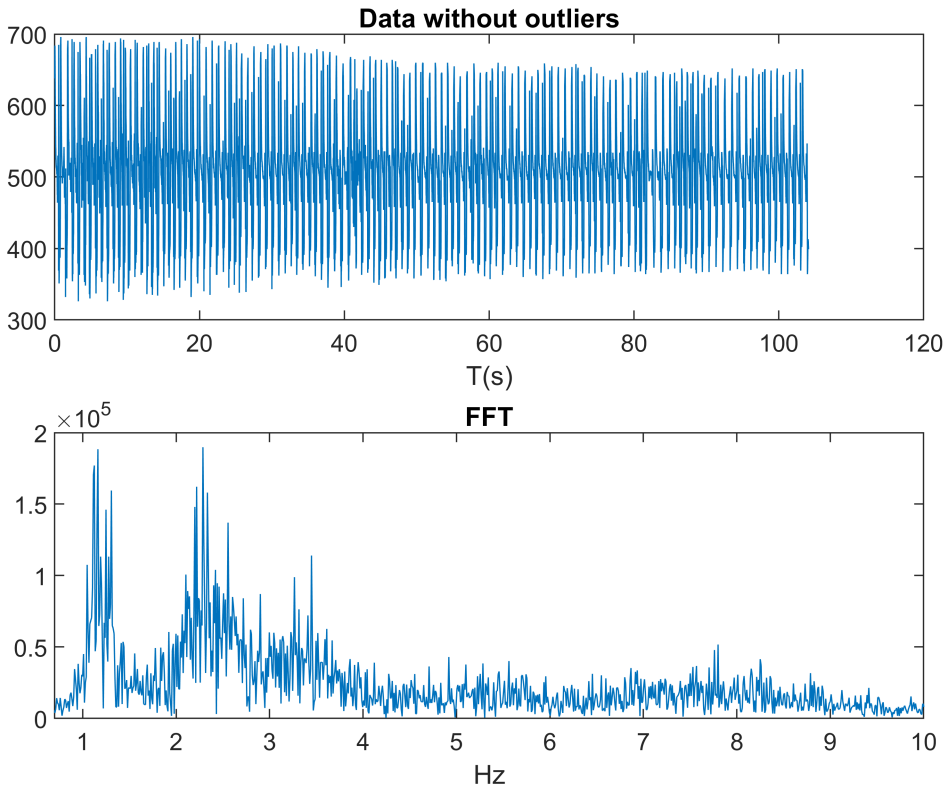

```
clear outlierIndices thresholdLow thresholdHigh center
```

Plots

```
figure,
subplot(211),plot(data_time, data_set_z)
title("Original data")
subplot(212),plot(data_time, outliers)
title("Data without outliers")
```




```
fft_outliers = fft(outliers - mean(outliers));

% Smooth input data
smoothedData = smoothdata(fft_outliers,"movmean",5);

figure,
subplot(211),plot(data_time, outliers)
title("Data without outliers"),xlabel("T(s)")
subplot(212),plot(f, abs(fft_outliers(1:numel(f)))*2)
title("FFT"),xlim([0.7, 10]),xlabel("Hz")
```

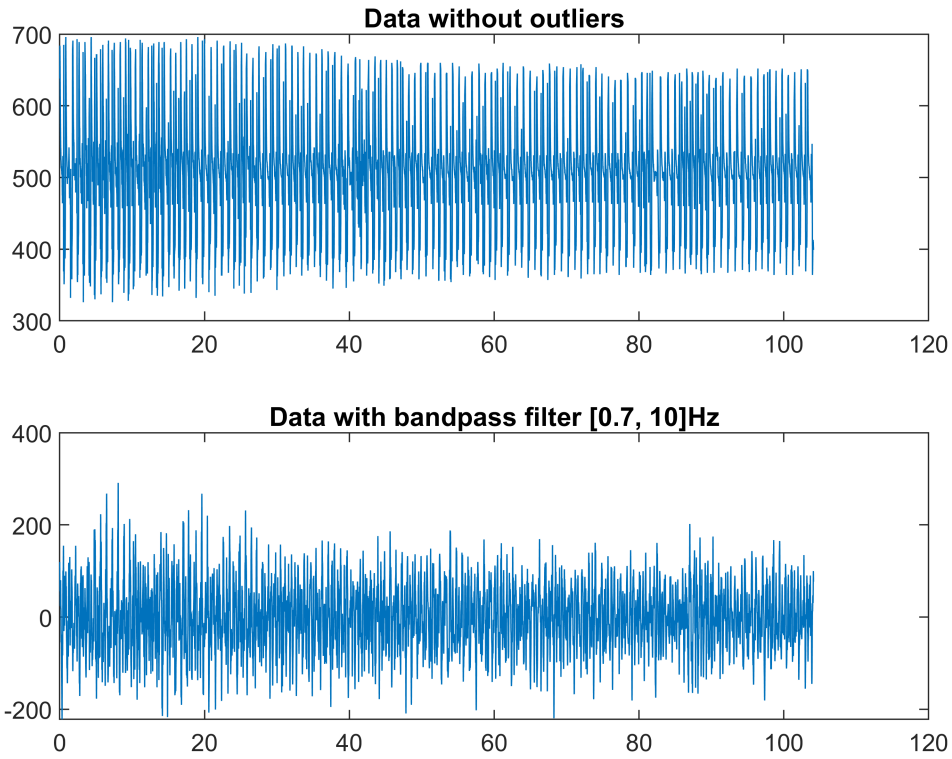


Bandpass filter [0.7 - 10]Hz

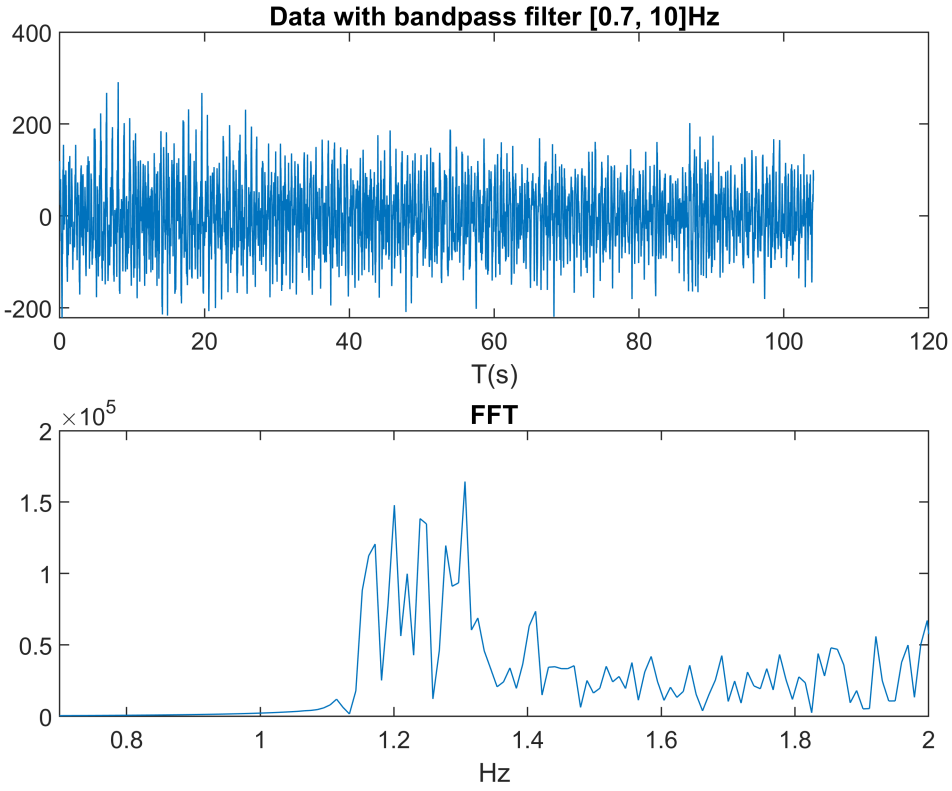
```
% Hd = butter_ecg(Fs);
% filtered = filter(Hd,outliers);
filtered = filter_bpm(outliers);
```

Plots

```
figure,
subplot(211),plot(data_time, outliers)
title("Data without outliers")
subplot(212),plot(data_time, filtered)
title("Data with bandpass filter [0.7, 10]Hz")
```




```
fft_filtered = fft(filtered);

figure,
subplot(211),plot(data_time, filtered)
title("Data with bandpass filter [0.7, 10]Hz"),xlabel("T(s)")
subplot(212),plot(f, abs(fft_filtered(1:numel(f)))*2)
title("FFT"),xlim([0.7, 2]),xlabel("Hz")
```




```
[~, I] = max(abs(fft_filtered(1:numel(f)))*2);
disp("Estimated frequency: " + f(I) + "Hz")
```

```
Estimated frequency: 2.286Hz
```

```
disp("Estimated BPM: " + f(I)*60)
```

```
Estimated BPM: 137.1626
```

Segmentation and Windowing

Segmentation

```
samples_15s = round(Fs*15);
samples_60s = samples_15s * 4;
[segmented, time_array] = segment_data(filtered,data_time,samples_60s,samples_15s);

f_segment = Fs*(0:(samples_60s/2))/samples_60s;

n = size(segmented,2)
```

```
n = 2
```

Windowing

```
windowed = hamming(samples_60s,"symmetric") .* segmented;
```

BPM

```
fft_windows = fft(windowed);
```

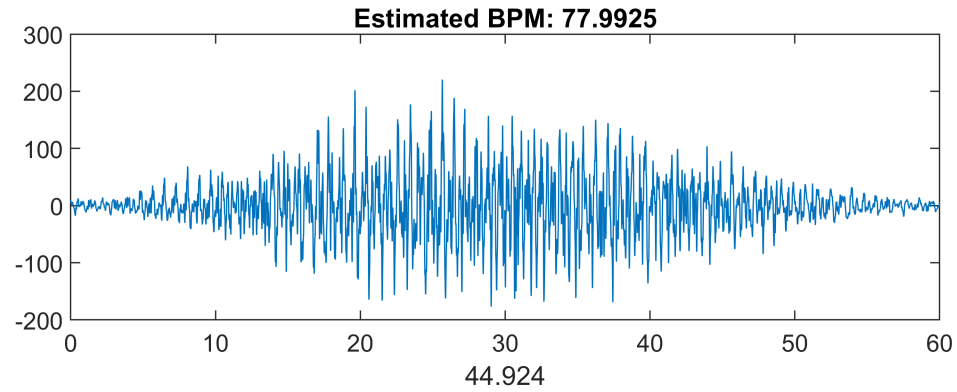
```
index_7 = find(f_segment>.7,1)
```

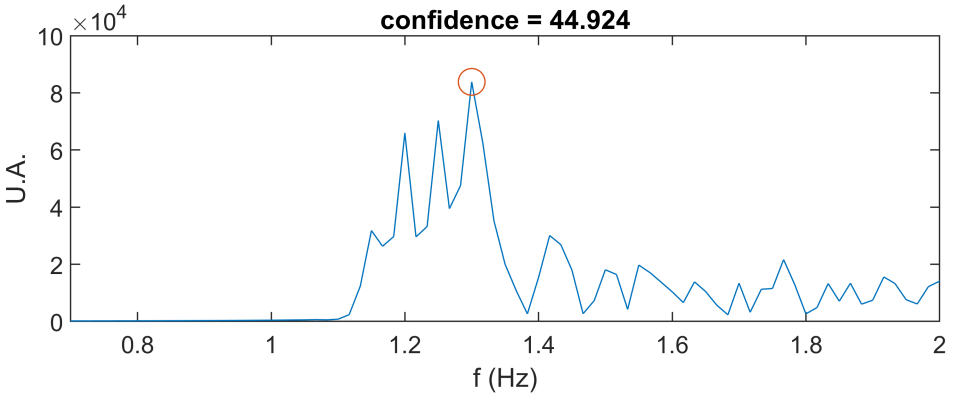
```
index_7 = 44
```

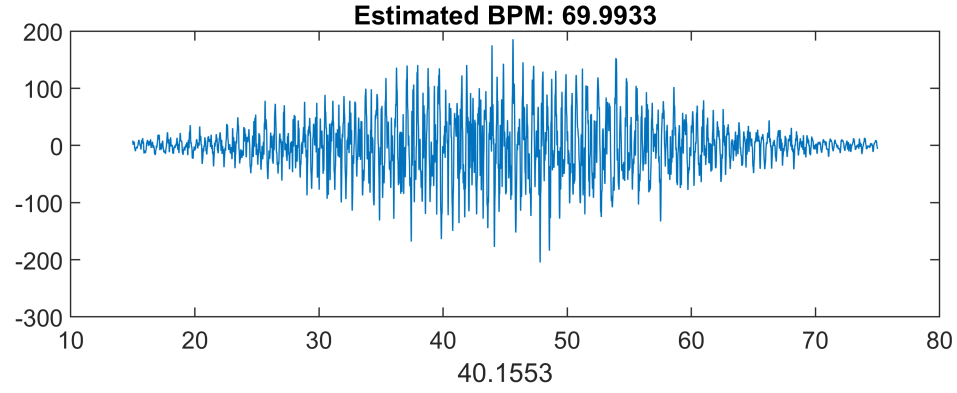
```
index_100 = find(f_segment<2,1,"last")
```

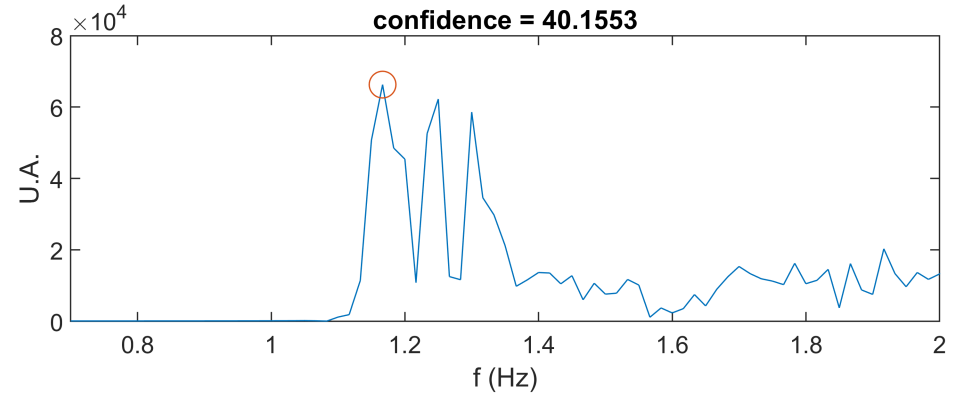
```
index_100 = 121
```

```
bpms = zeros(1,n);
figure
for count = 1:n
    figure
    fft_cut = fft_windows(1:numel(f_segment),count);
    [M, I] = max(abs(fft_cut(index_7:index_100))*2);
    bpms(count) = f_segment(I+index_7-1)*60;

    subplot(211)
    plot(time_array(:,count),windowed(:,count))
    title("Estimated BPM: "+bpms(count))
    conf = confidence(fft_windows(1:numel(f_segment),count),f_segment,0.7,2);
    xlabel(conf)

    subplot(212)

    if conf > 25
        plot(f_segment, abs(fft_cut)*2)
    else
        plot(f_segment, abs(fft_cut)*2, "r")
    end
    xlim([0.7, 2])
    title("confidence = " + conf)
    xlabel("f (Hz)"),ylabel("U.A.")

    hold on
    plot(f_segment(I+index_7-1), M, 'o', 'MarkerSize', 10)
end
```









Hilbert Transform

```
ht_data = abs(hilbert(windowed)).^2;
```

Fourier Transform

```
fft_data = fft(ht_data);
```

BPM

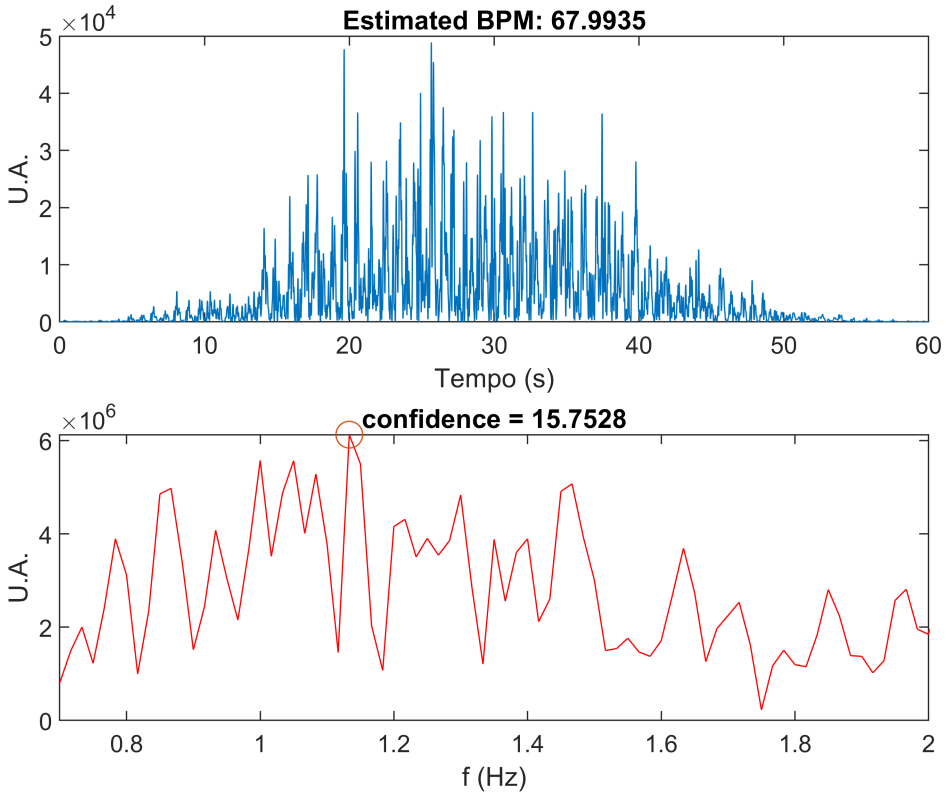
```
bpms = zeros(1,n);

index_7 = find(f_segment>.7,1)
```

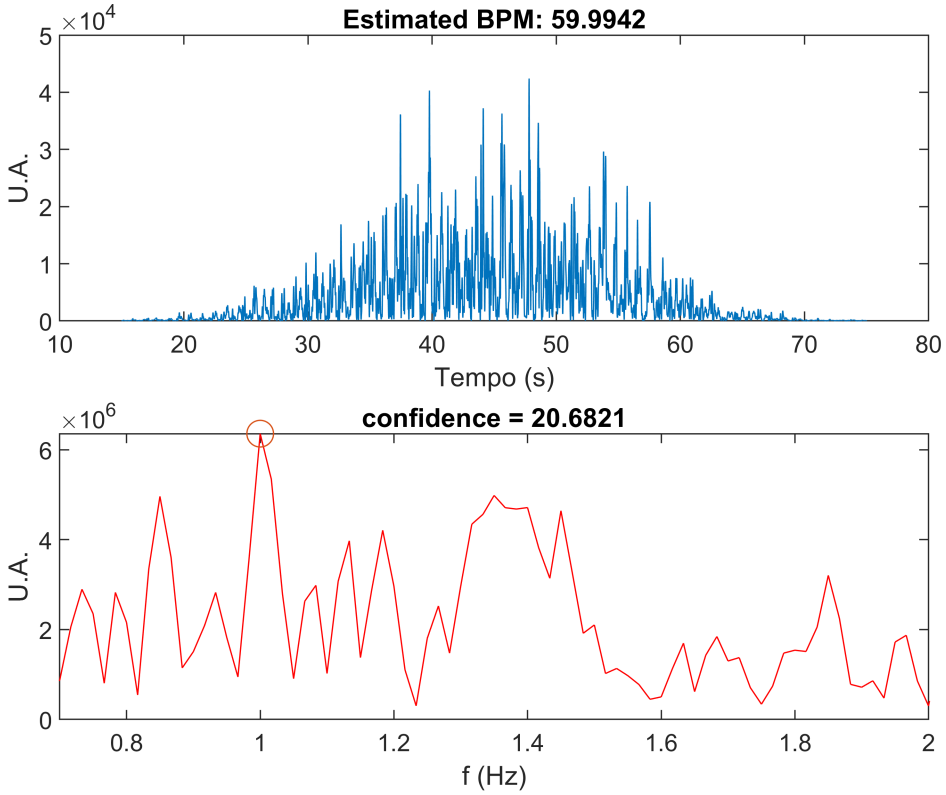
```
index_7 = 44
```

```
index_100 = find(f_segment<2,1,"last")
```

```
index_100 = 121
```

```

figure
for count = 1:n
    figure
    fft_cut = fft_data(1:numel(f_segment),count);
    [M, I] = max(abs(fft_cut(index_7:index_100))*2);
    bpms(count) = f_segment(I+index_7-1)*60;

    subplot(211)
    plot(time_array(:,count),ht_data(:,count))
    title("Estimated BPM: "+bpms(count))
    xlabel("Tempo (s)"),ylabel("U.A.")

    conf = confidence(fft_cut,f_segment,0.7,2);
    subplot(212)
    if conf > 25
        plot(f_segment, abs(fft_cut)*2)
    else
        plot(f_segment, abs(fft_cut)*2, "r")
    end
    xlim([0.7, 2])
    title("confidence = " + conf)
    xlabel("f (Hz)"),ylabel("U.A.")

    hold on
    plot(f_segment(I+index_7-1), M, 'o', 'MarkerSize', 10)
    disp("--------------------------------------------------------------------------------")
end
```


Estimated BPM: 67.9935
×10^4
U.A.
Tempo (s)
confidence = 15.7528
×10^6
U.A.
f (Hz)


Estimated BPM: 59.9942
×10^4
U.A.
Tempo (s)
confidence = 20.6821
×10^6
U.A.
f (Hz)
