

DSP Simulation Assignment 2

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1) Gathering the audio files

```
clc
clear all
close all

myDir = uigetdir; %gets directory
% Add that folder plus all subfolders to the path.
addpath(genpath(myDir));
myFiles = dir(fullfile(myDir, '**\*.wav')); %gets all wav files in struct
```

2) Construction of the Filters

```
Nfilters = 50; %Number of Samples
Fs = 8000; %Sampling Frequency
flag = 1;

%Generating the filter lower and upper cutoff frequencies
z1 = linspace(0,1000,Nfilters/2+1);
z2 = linspace(1000,4000,Nfilters/2+1);
z = unique([z1 z2]);

%Defining the 5-th order Butterworth Filters
for i = 1:Nfilters
    if (i==1)
        [b{i}, a{i}] = butter(5,z(i+1)/(Fs/2));
    elseif (i==Nfilters)
        [b{i}, a{i}] = butter(5,z(i)/(Fs/2), 'high');
    else
        [b{i}, a{i}] = butter(5,[z(i)/(Fs/2),z(i+1)/(Fs/2)], 'bandpass');
    end
    %figure
    %freqz(b{i}, a{i}, 100, Fs); %Optional plotting filter response
end
fprintf(1, 'Filters Ready \n');
```

Filters Ready

```
drawnow
labels = [];
ucat = [];
```

3) Reading Files and Preparing Labels

```
for k = 1:length(myFiles)
    baseFileName = myFiles(k).name;
    fullFileName = fullfile(myFiles(k).folder, baseFileName);
    [~,voice] = fileparts(myFiles(k).folder);

    fprintf(1, 'Now reading %s by %s\n', baseFileName, voice);
```

```

c = myFiles(k).name(1);
e = myFiles(k).name(end-4);
if c=='m'
    newlabel = voice + "-M" + e;
    newcat = voice + "-Morning";
else
    newlabel = voice + "-A" + e;
    newcat = voice + "-Afternoon";
end
labels = [labels newlabel];
ucat = [ucat newcat];
[x, Fs] = audioread(fullFileName);

```

4) Computing Pitch of the Recorded Speech

```

windowLength = round(0.03*Fs);
overlapLength = round(0.025*Fs);
[f0,idx] = pitch(x,Fs,'WindowLength',windowLength,'OverlapLength',overlapLength); %MATLAB pitch
hr = harmonicRatio(x,Fs,"Window",hamming(windowLength,'periodic'),'OverlapLength',overlapLength);

f0(hr < 0.5) = nan; %Discard pitch where Harmonic Ratio < 0.5
f0 = medfilt1(f0,10); %Apply median filter of length 10 samples
M = mean(f0,'omitnan');

```

5) Plotting Speech Signal, Spectrogram and Temporal Detected Pitch

```

%N = 512; %Number of points in DFT
t = linspace(0,1,length(x))*length(x)/Fs;

figure
tiledlayout(3,1)

nexttile
plot(t,x);
xlim([0 t(length(t))]);
%ylim([-1 1]);
title("Time Domain Audio Signal " + newlabel);
xlabel('Time(sec)');
ylabel('y(t)');

nexttile
spectrogram(x,windowLength,overlapLength,windowLength,Fs,'yaxis');
xlim([0 t(length(t))]);
title("Spectrogram of sampled signal " + newlabel);

nexttile
plot(idx/Fs,f0,'LineWidth',3);
xlim([0 t(length(t))]);
ylim([80 280]);
title("Estimated Pitch of " + voice + " = " + M);
xlabel({'Time(sec)', " ", strcat("Fig: Speech Characteristics of Current Sample")});
ylabel('Pitch(Hz)');
saveas(gcf, strcat("plots_",baseFileName, voice,".png"))

```

6) Filtering the Speech Signal through Linearly Spaced Butterworth Filter Banks and computing energy

```
%figure
for i= 1:Nfilters
    y = filter(b{i},a{i},x);

    %     subplot(Nfilters/2,2,i);
    %     plot(t,y);
    %     xlim([0 t(length(t))])
    %     %ylim([-1 1]);
    %     title("Filter bank output of " + newlabel + " for filter " + i );
    %     xlabel('Time(sec)');
    %     ylabel('y(t)');

    energy(k,i) = sumsqr(y); %Energy as sum of squared values
    clear y;
end
energy(k,:) = energy(k,+)/max(energy(k,:)); %Normalizing the energy w.r.t maximum energy of
```

Note :- Energy(k,i) denotes the energy of k-th sample in i-th filter bank. Energy2 is average of energy for 4 different samples (for each person in morning/afternoon)

end

Now reading afti1.wav by Nivedita

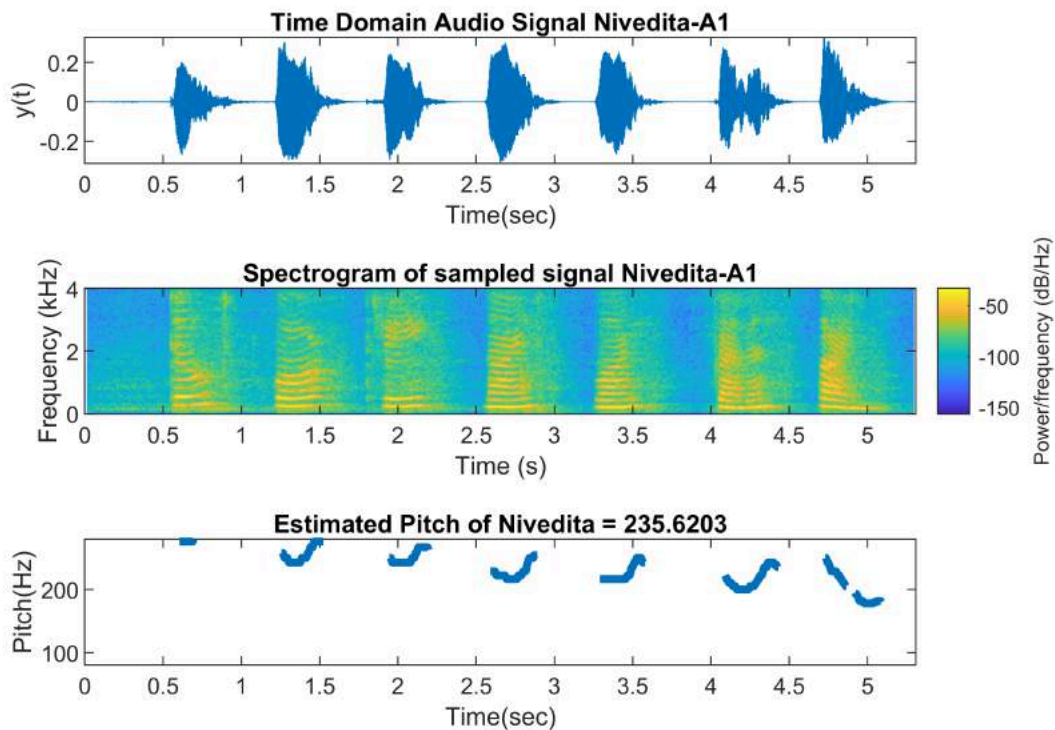


Fig: Speech Characteristics of Current Sample

Now reading afti2.wav by Nivedita

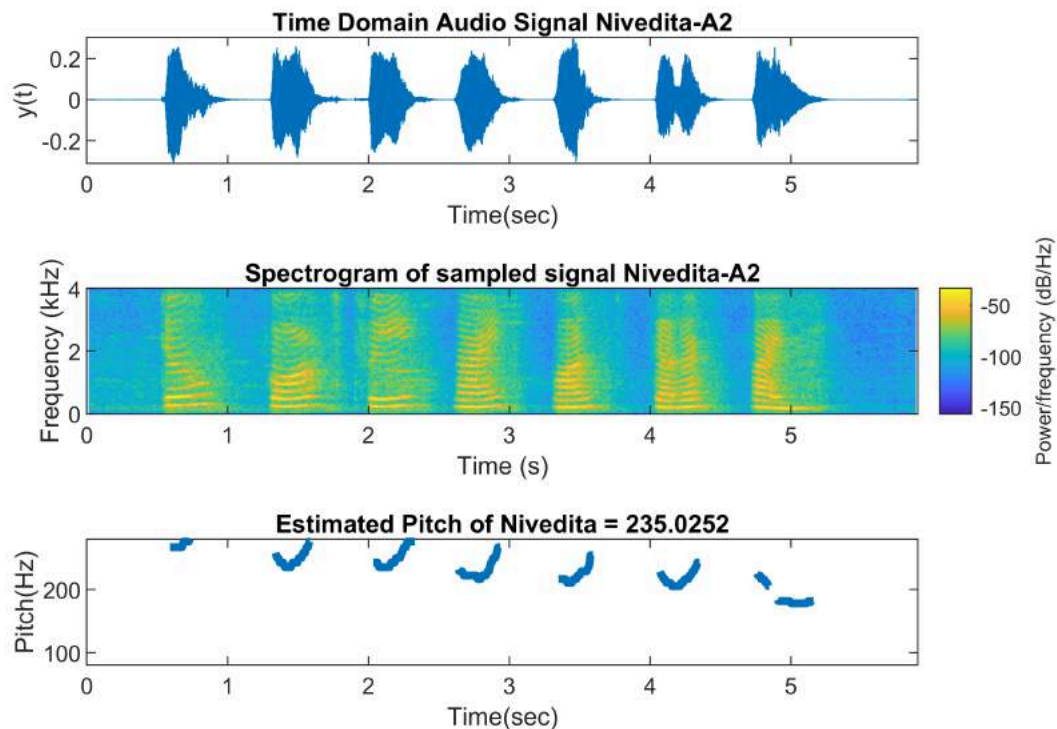


Fig: Speech Characteristics of Current Sample

Now reading afti3.wav by Nivedita

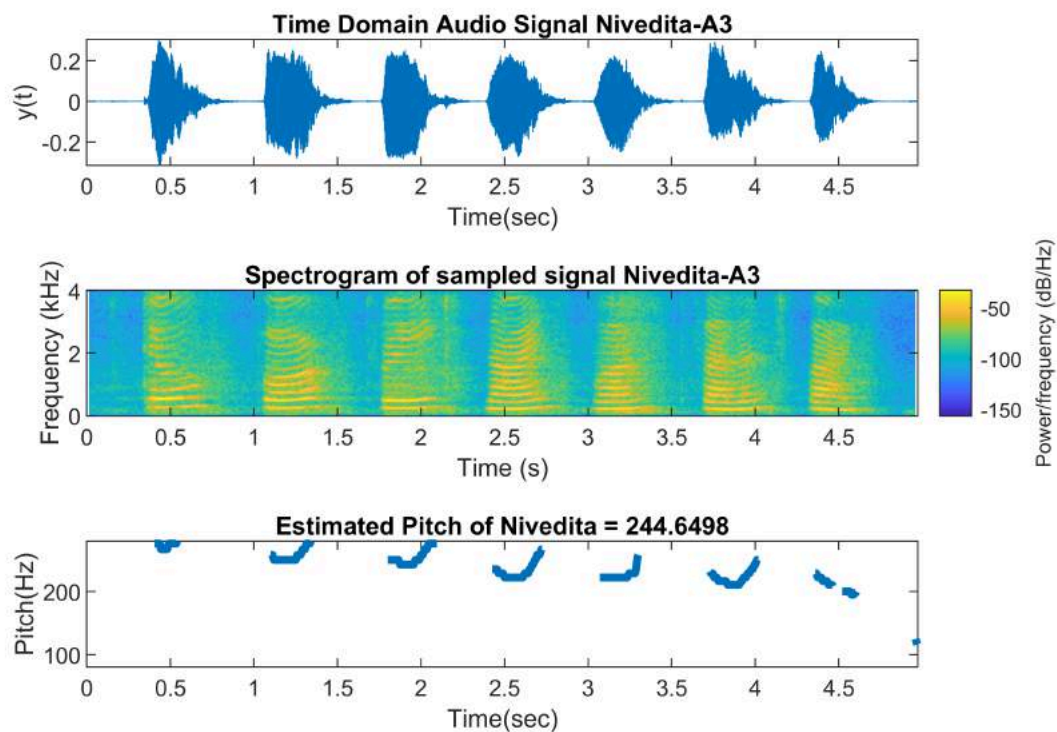


Fig: Speech Characteristics of Current Sample

Now reading afti4.wav by Nivedita

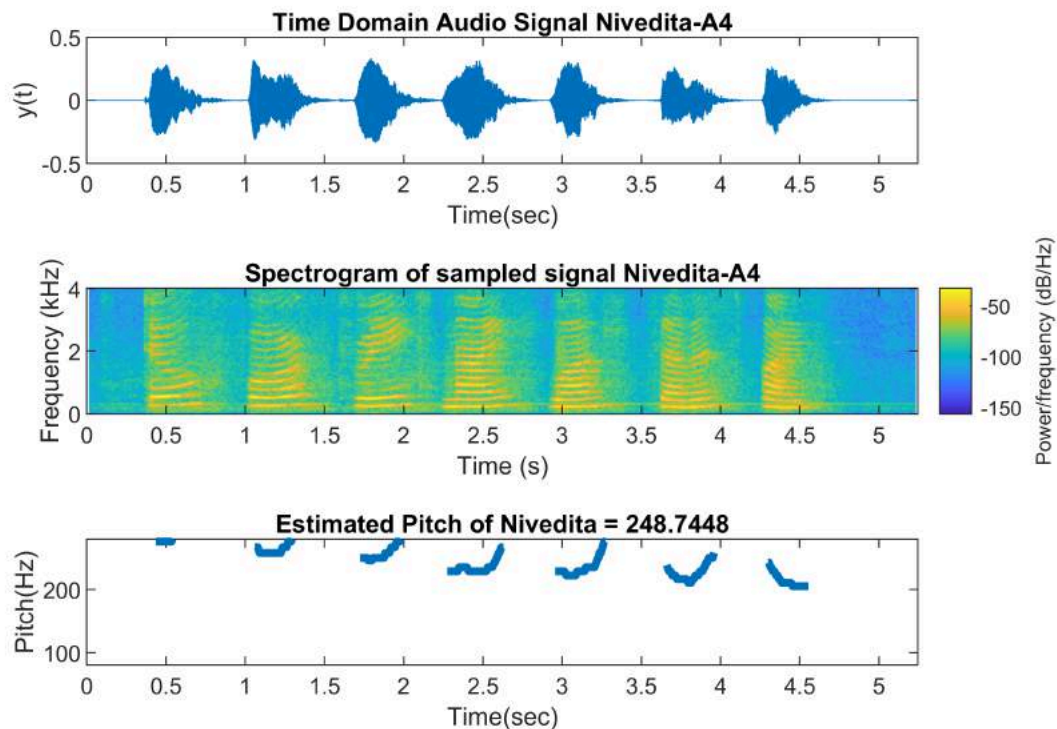


Fig: Speech Characteristics of Current Sample

Now reading morn1.wav by Nivedita

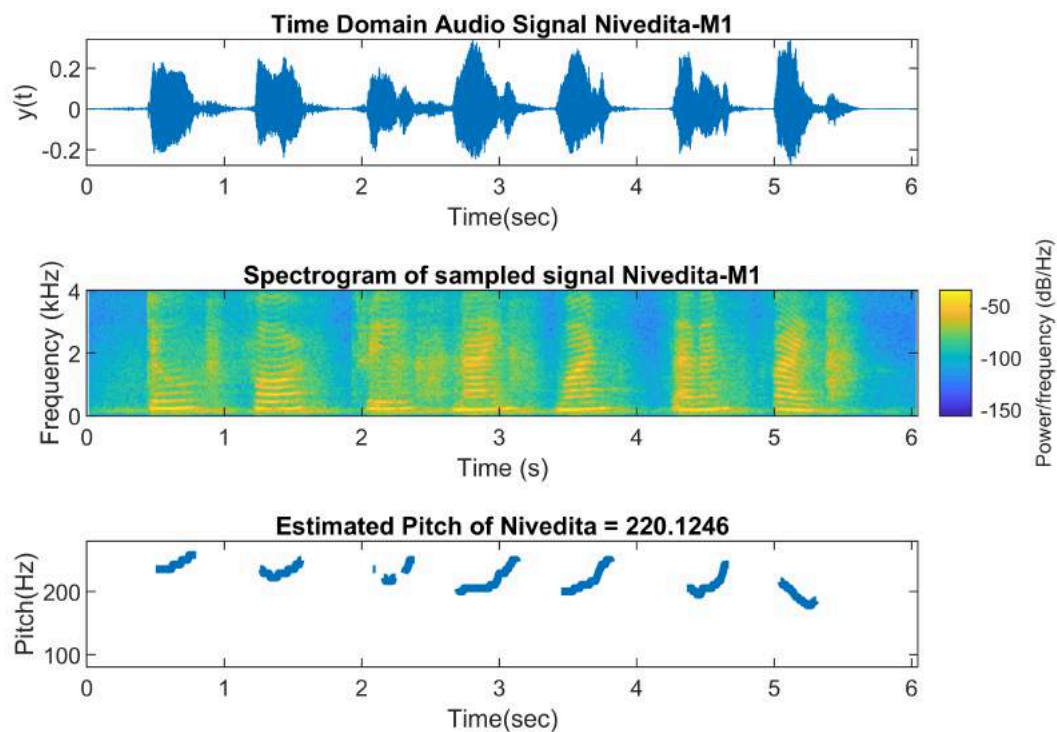


Fig: Speech Characteristics of Current Sample

Now reading morn2.wav by Nivedita

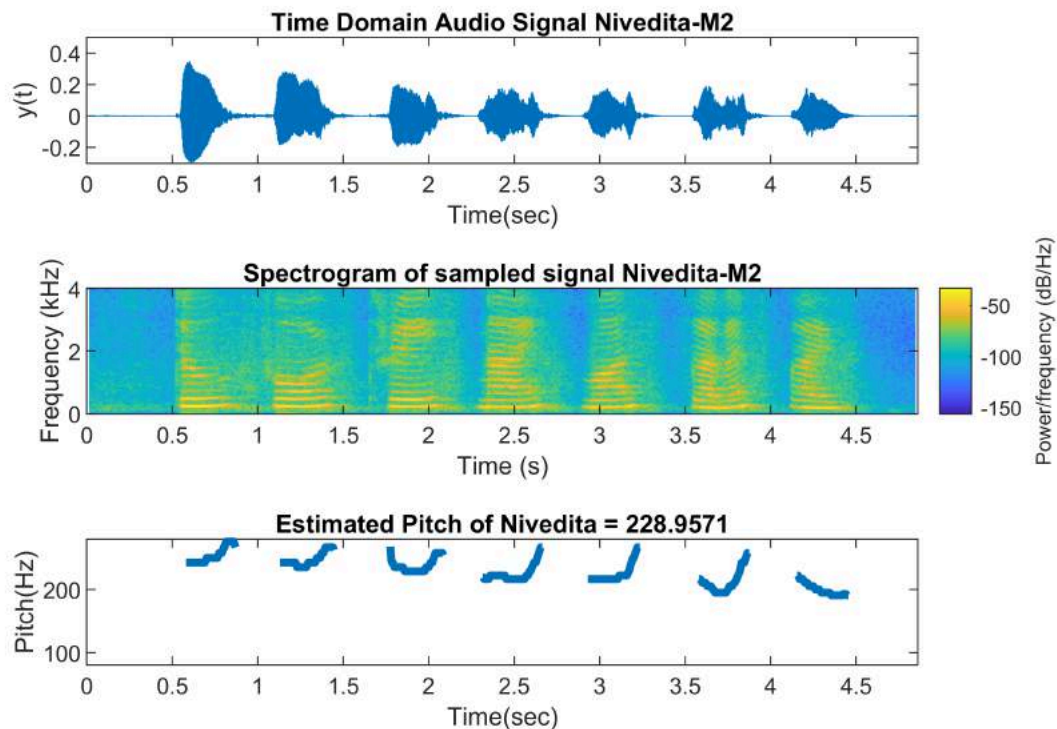


Fig: Speech Characteristics of Current Sample

Now reading morn3.wav by Nivedita

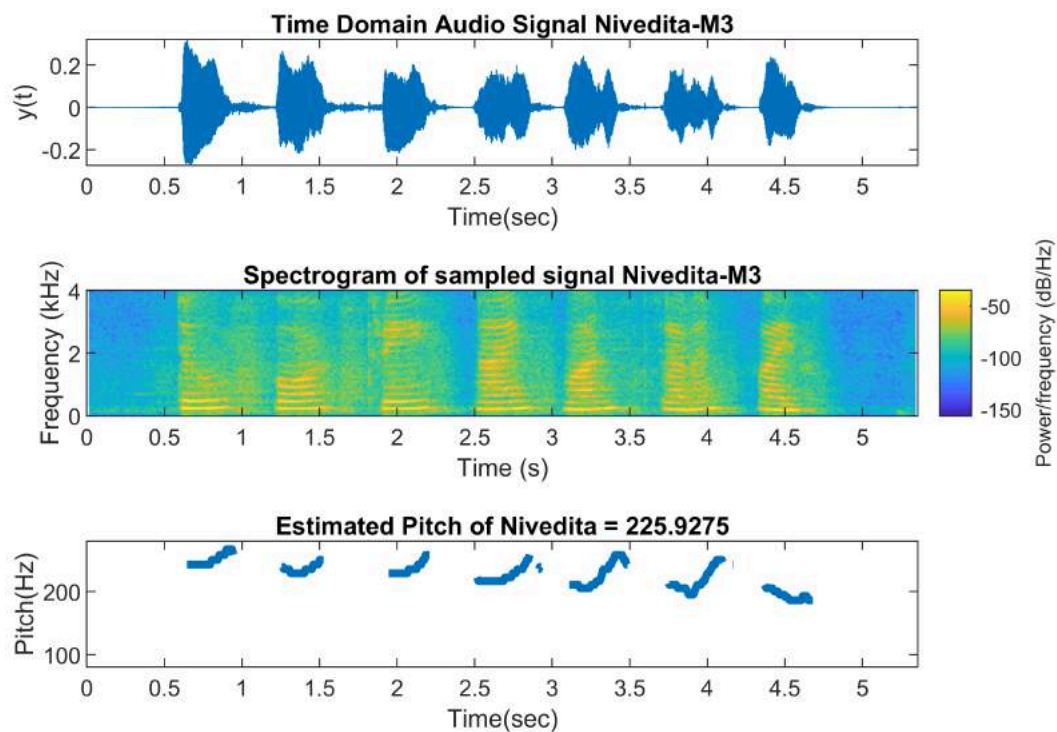


Fig: Speech Characteristics of Current Sample

Now reading morn4.wav by Nivedita

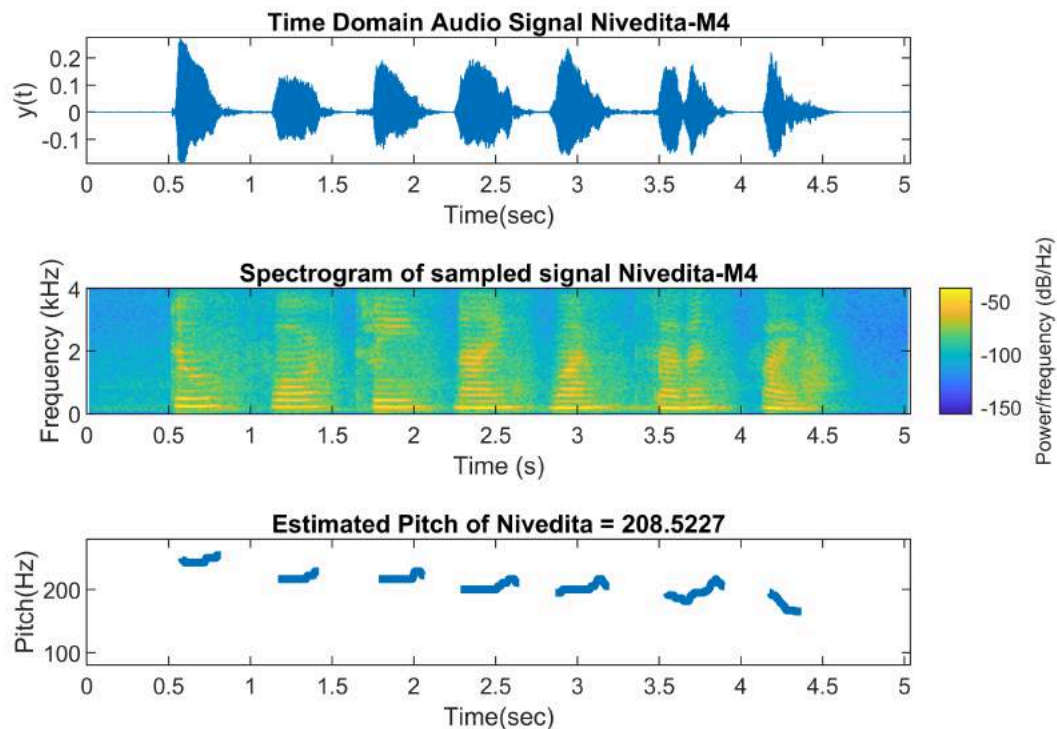


Fig: Speech Characteristics of Current Sample

Now reading afti1.wav by Prerna

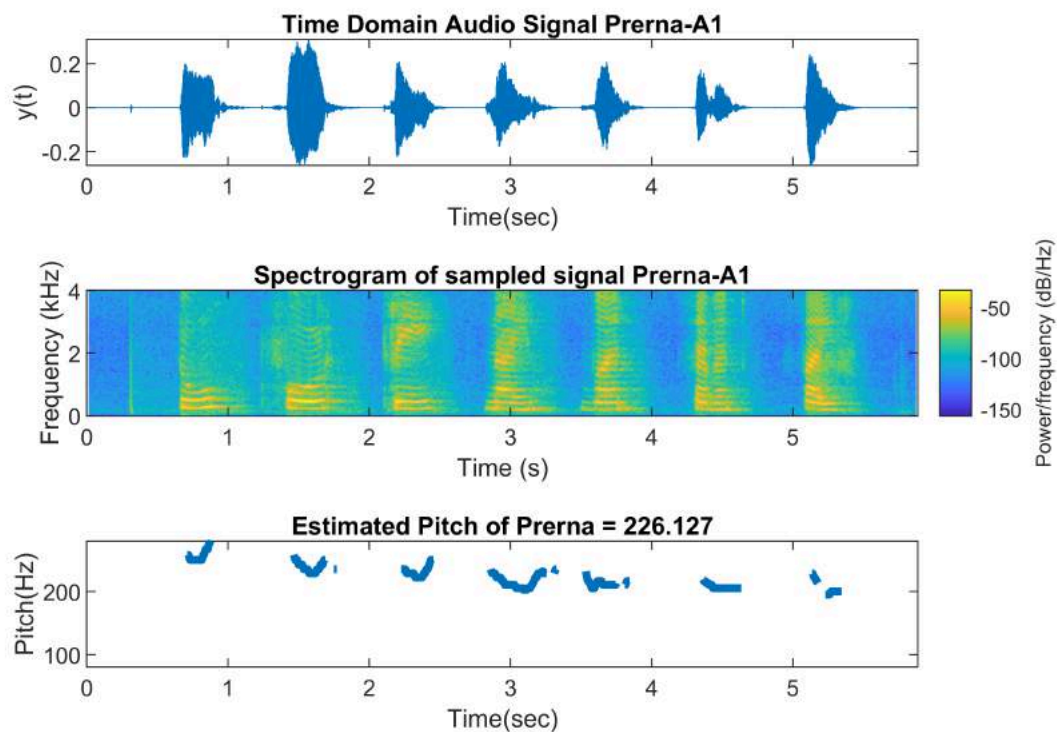


Fig: Speech Characteristics of Current Sample

Now reading afti2.wav by Prerna

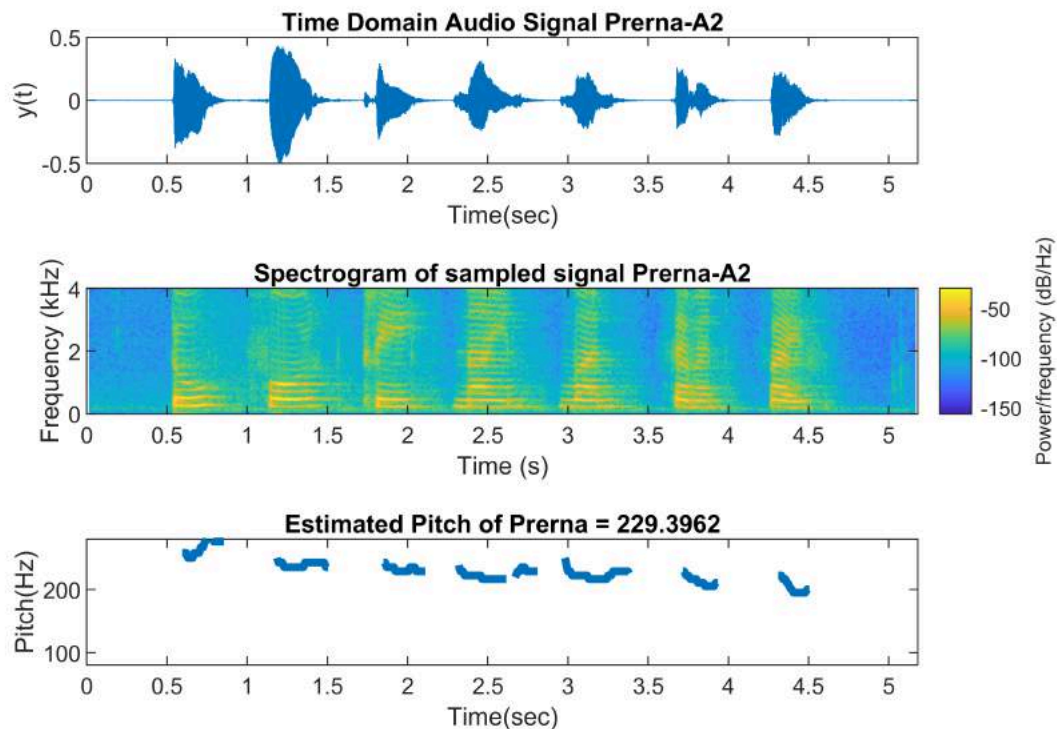


Fig: Speech Characteristics of Current Sample

Now reading afti3.wav by Prerna

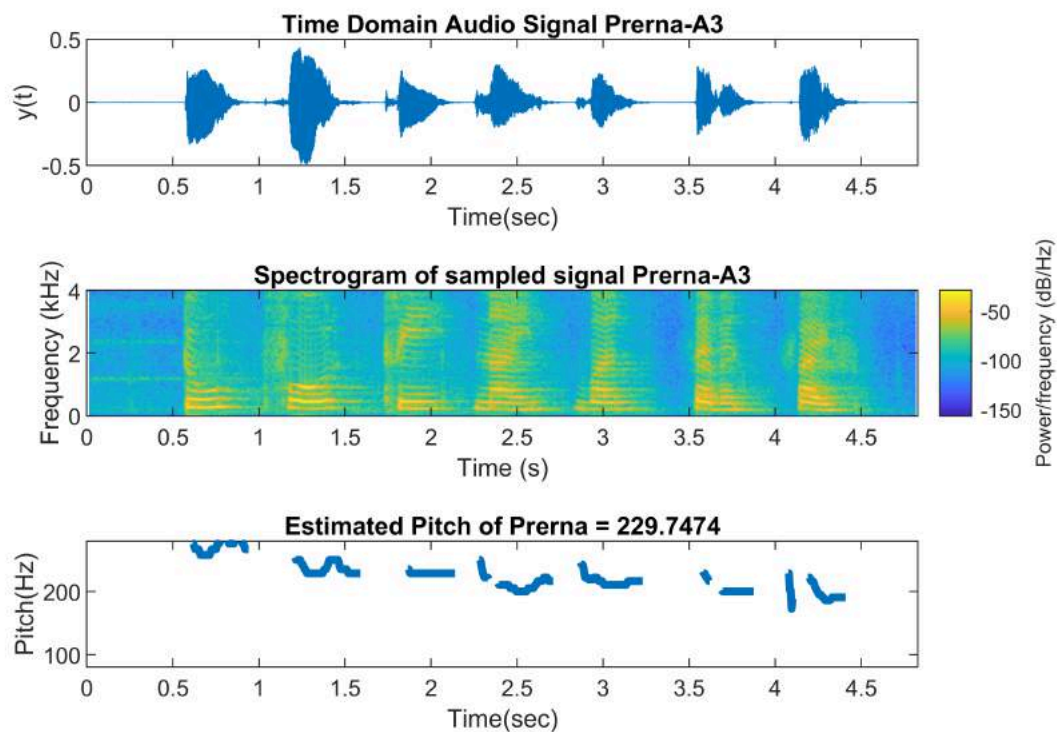


Fig: Speech Characteristics of Current Sample

Now reading afti4.wav by Prerna

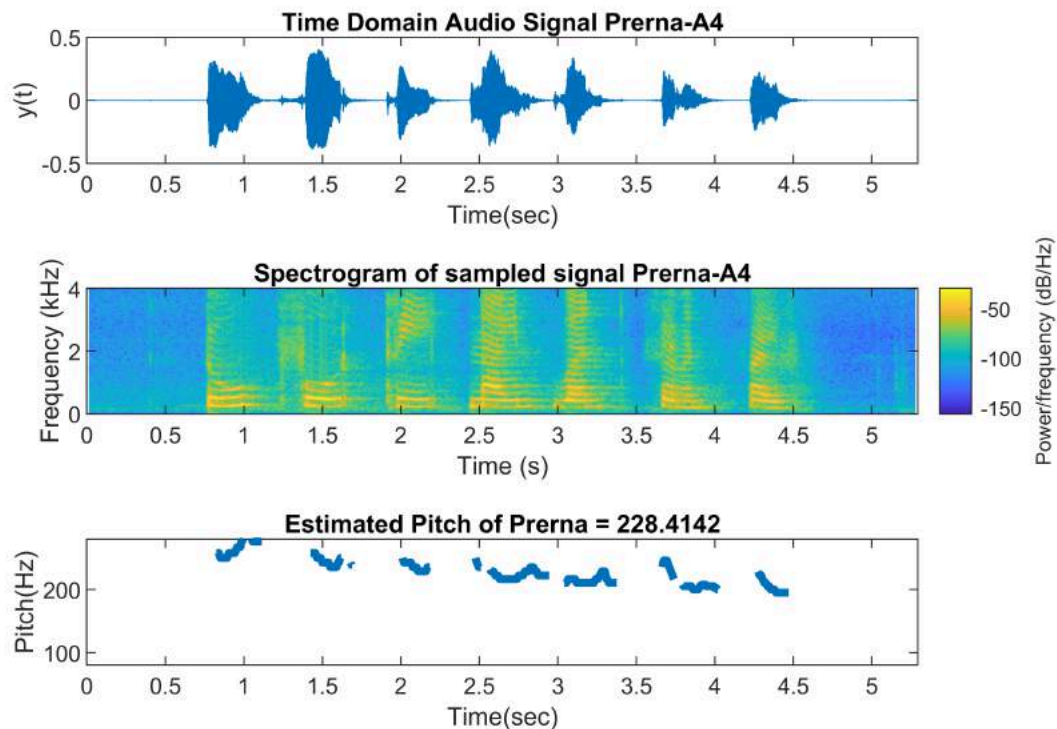


Fig: Speech Characteristics of Current Sample

Now reading morning1.wav by Prerna

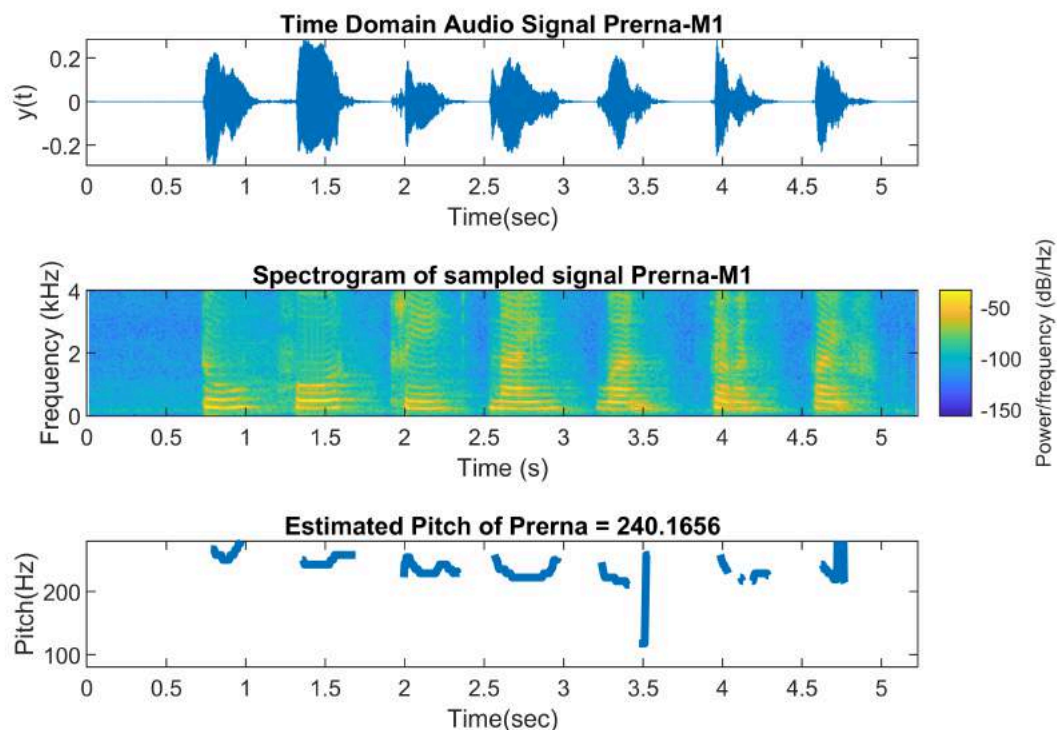


Fig: Speech Characteristics of Current Sample

Now reading morning2.wav by Prerna

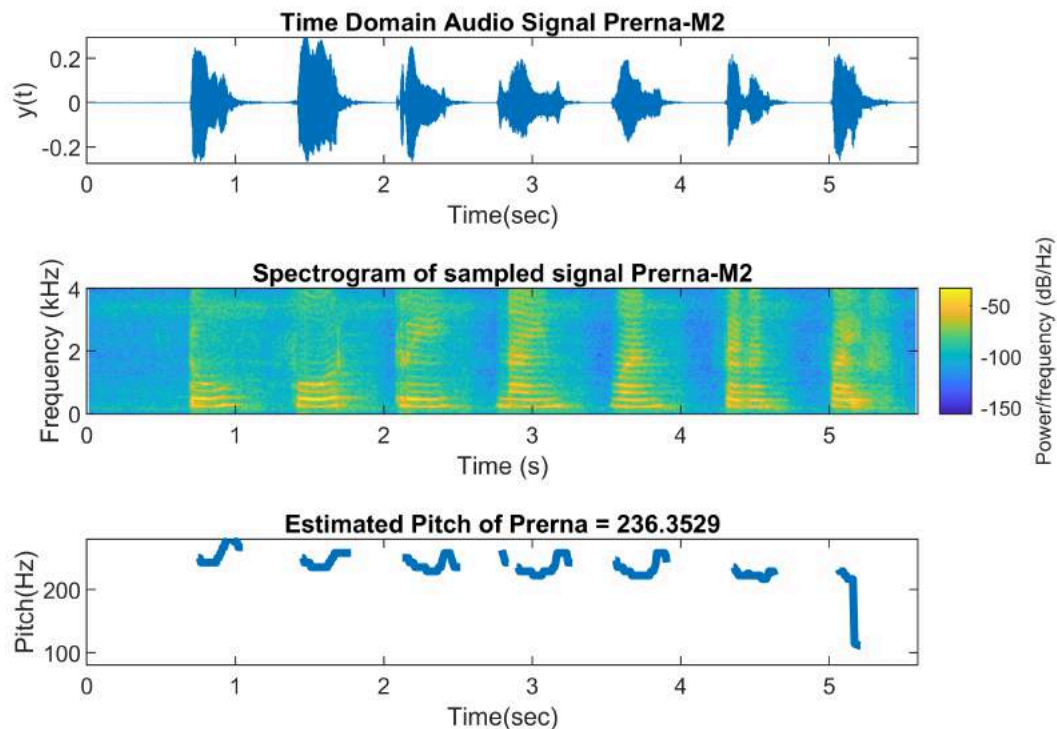


Fig: Speech Characteristics of Current Sample

Now reading morning3.wav by Prerna

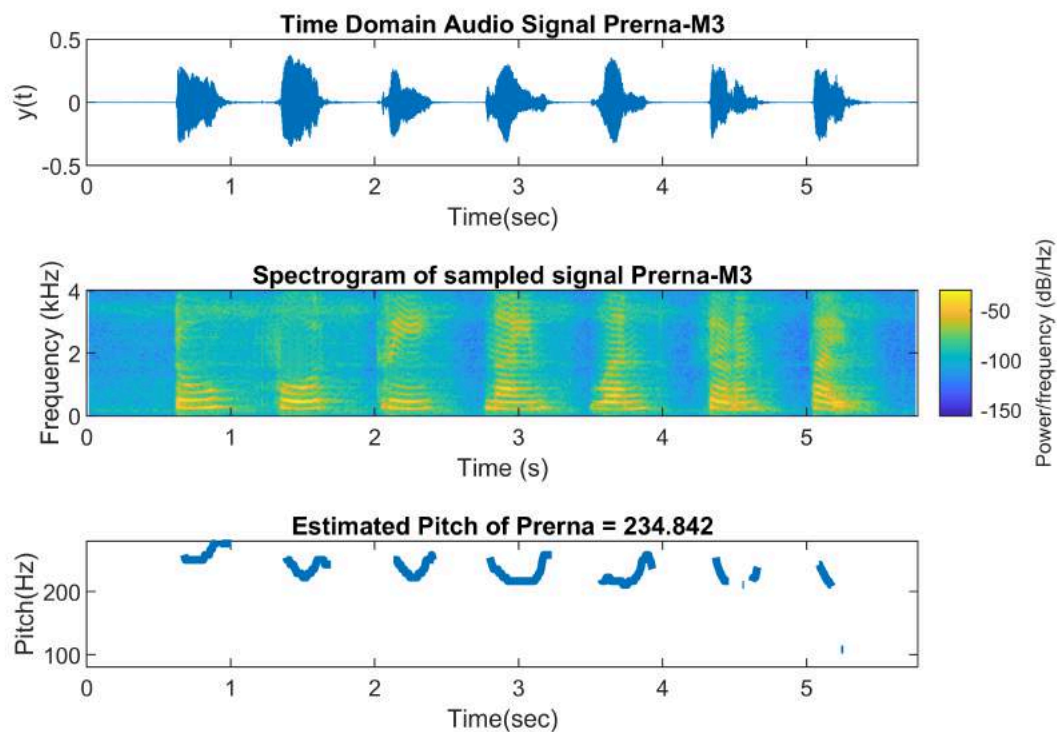


Fig: Speech Characteristics of Current Sample

Now reading morning4.wav by Prerna

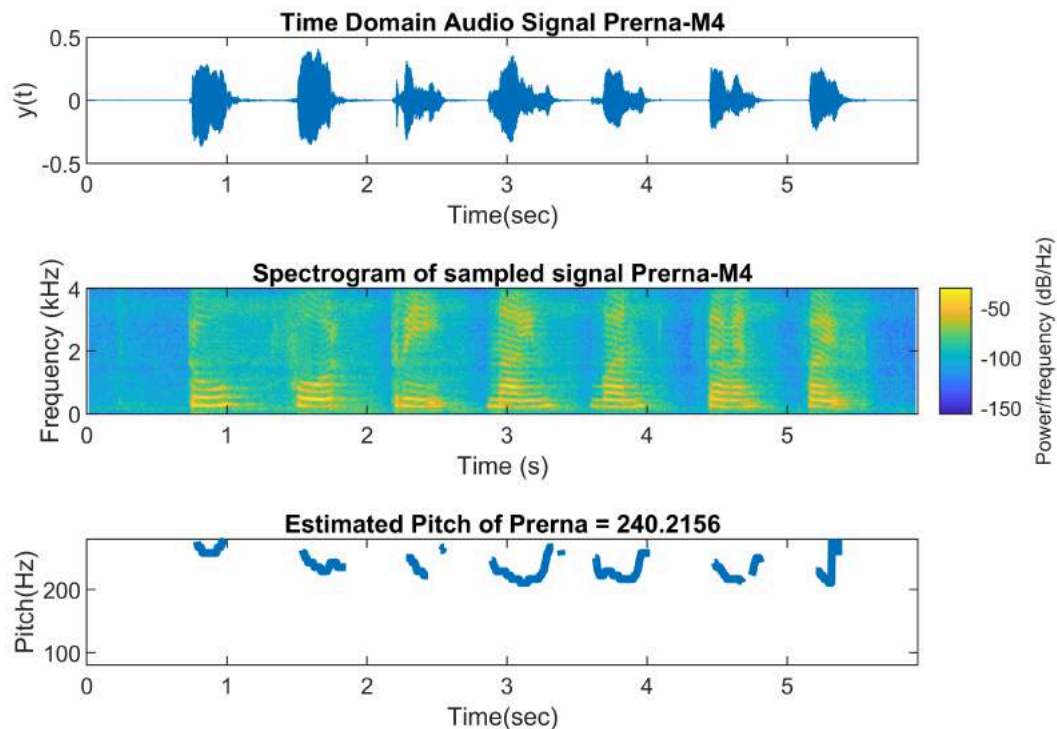


Fig: Speech Characteristics of Current Sample

Now reading Afterlunch_1.wav by Rudrajyoti

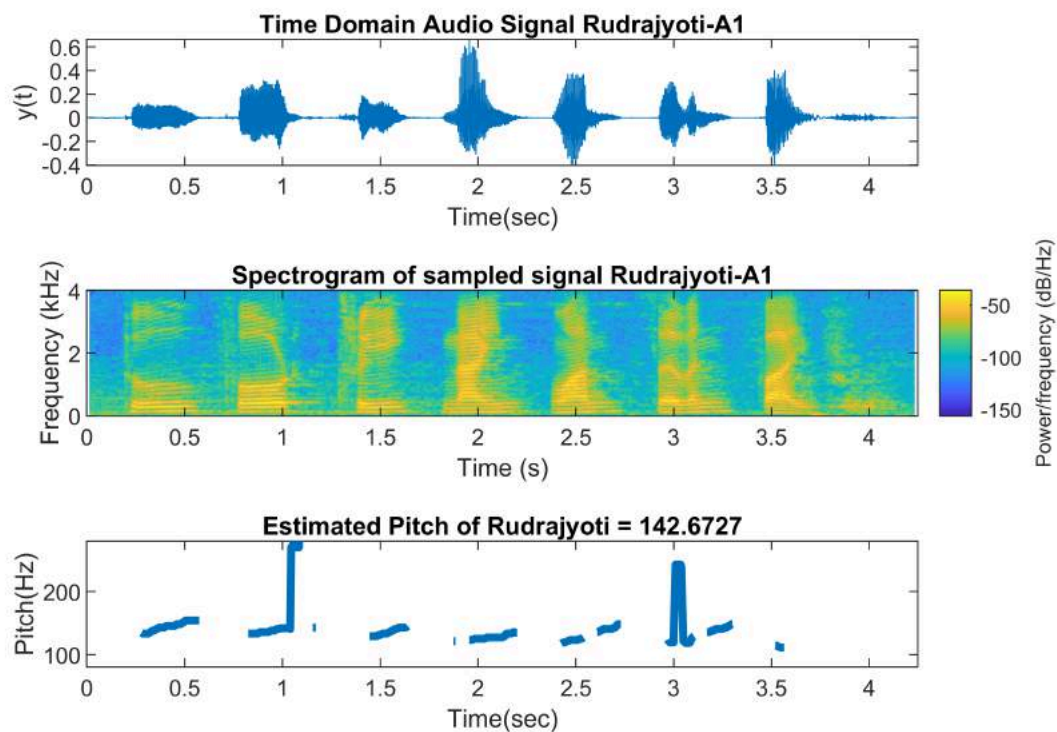


Fig: Speech Characteristics of Current Sample

Now reading Afterlunch_2.wav by Rudrajyoti

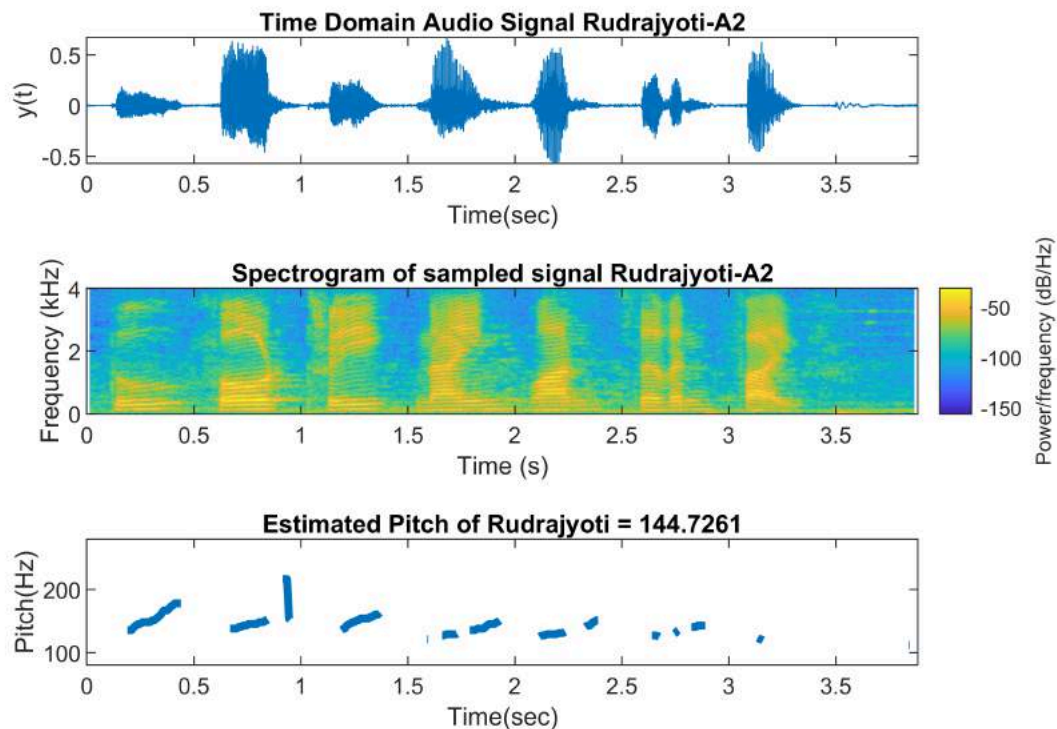


Fig: Speech Characteristics of Current Sample

Now reading Afterlunch_3.wav by Rudrajyoti

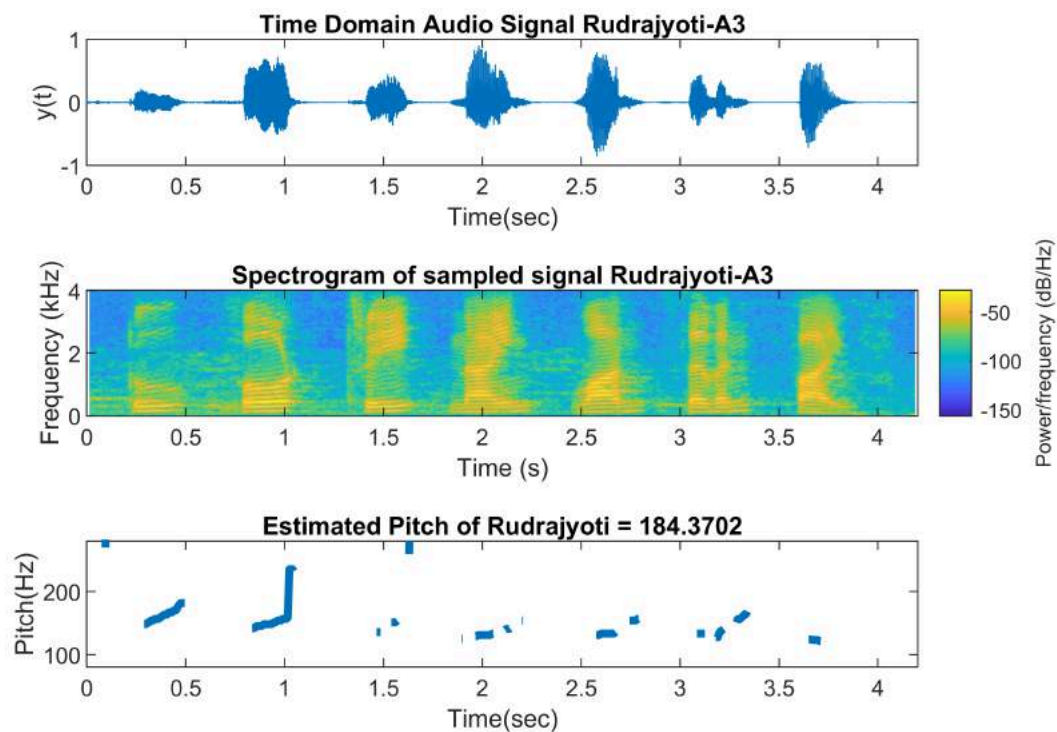


Fig: Speech Characteristics of Current Sample

Now reading Afterlunch_4.wav by Rudrajyoti

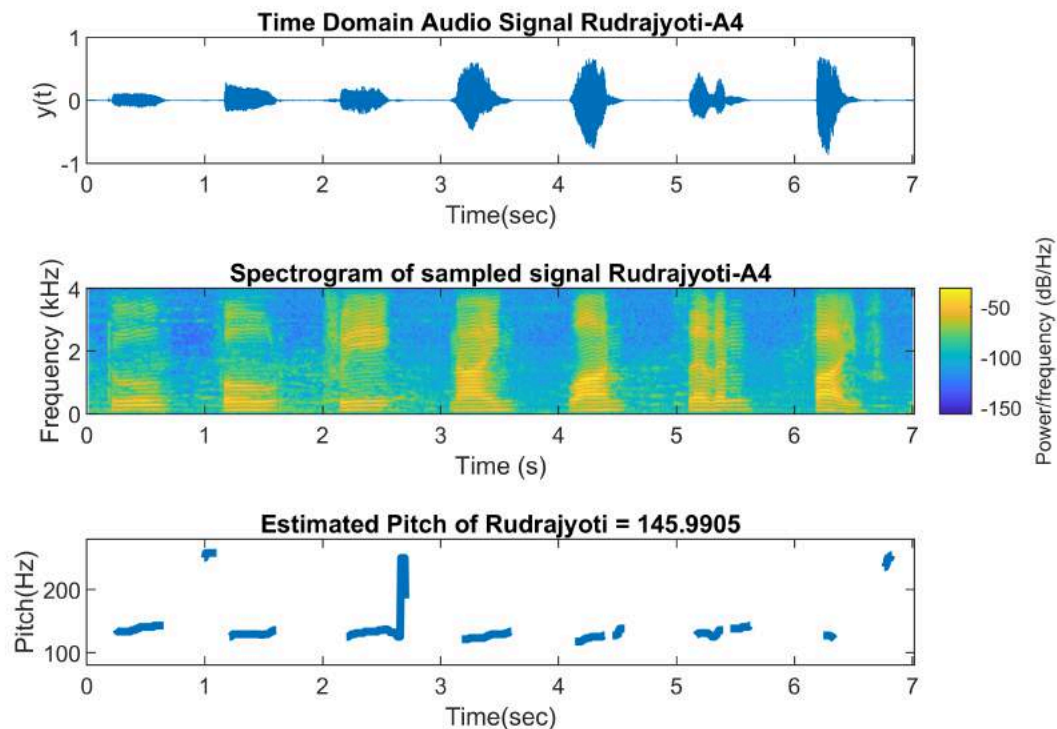


Fig: Speech Characteristics of Current Sample

Now reading morning_1.wav by Rudrajyoti

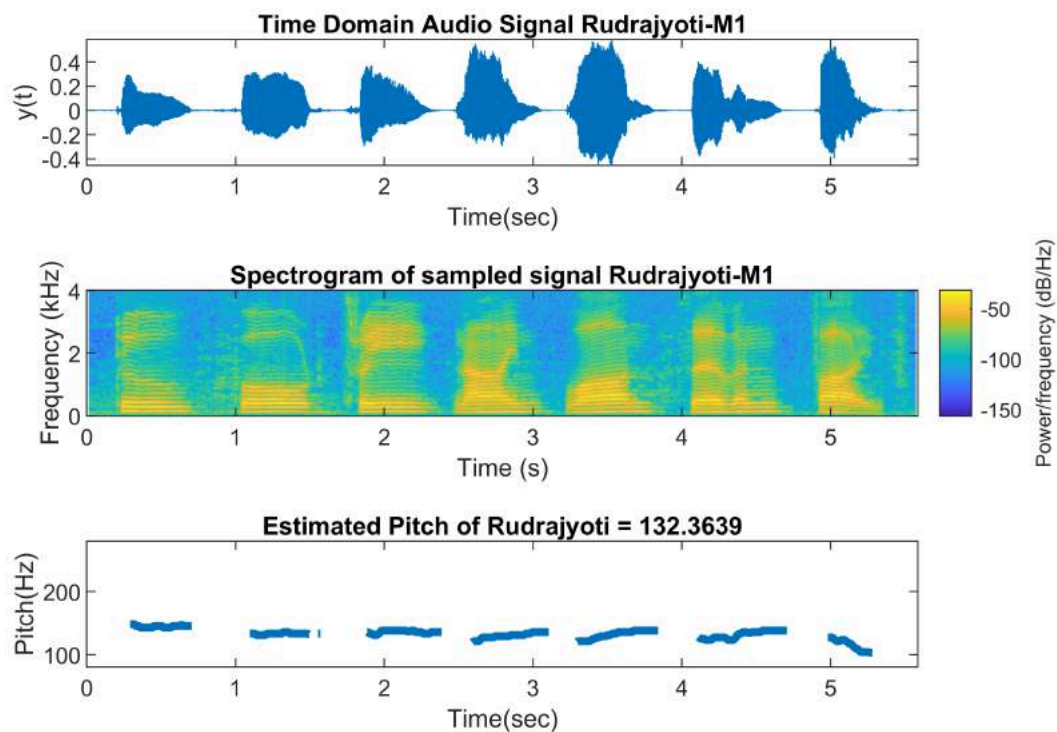


Fig: Speech Characteristics of Current Sample

Now reading morning_2.wav by Rudrajyoti

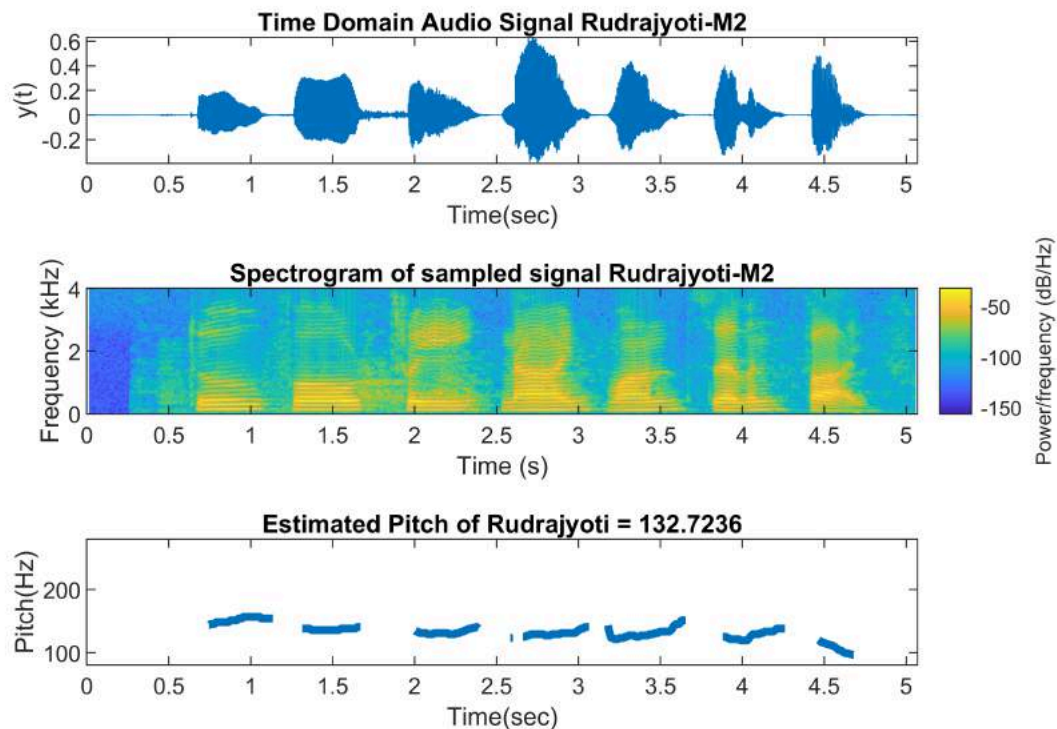


Fig: Speech Characteristics of Current Sample

Now reading morning_3.wav by Rudrajyoti

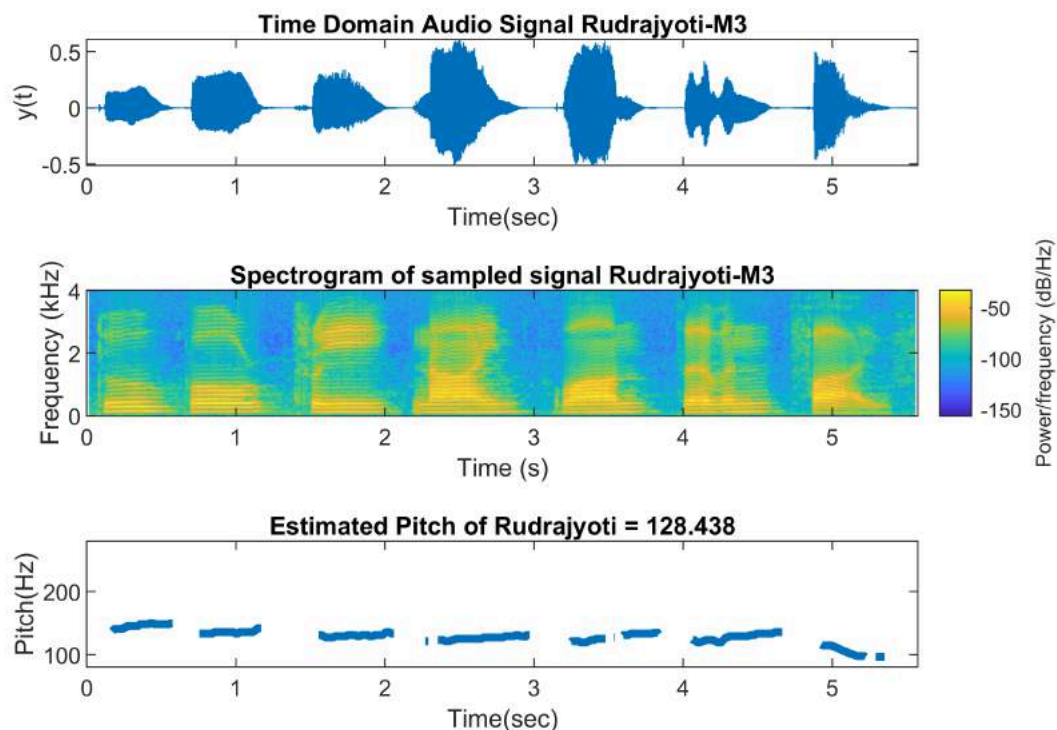


Fig: Speech Characteristics of Current Sample

Now reading morning_4.wav by Rudrajyoti

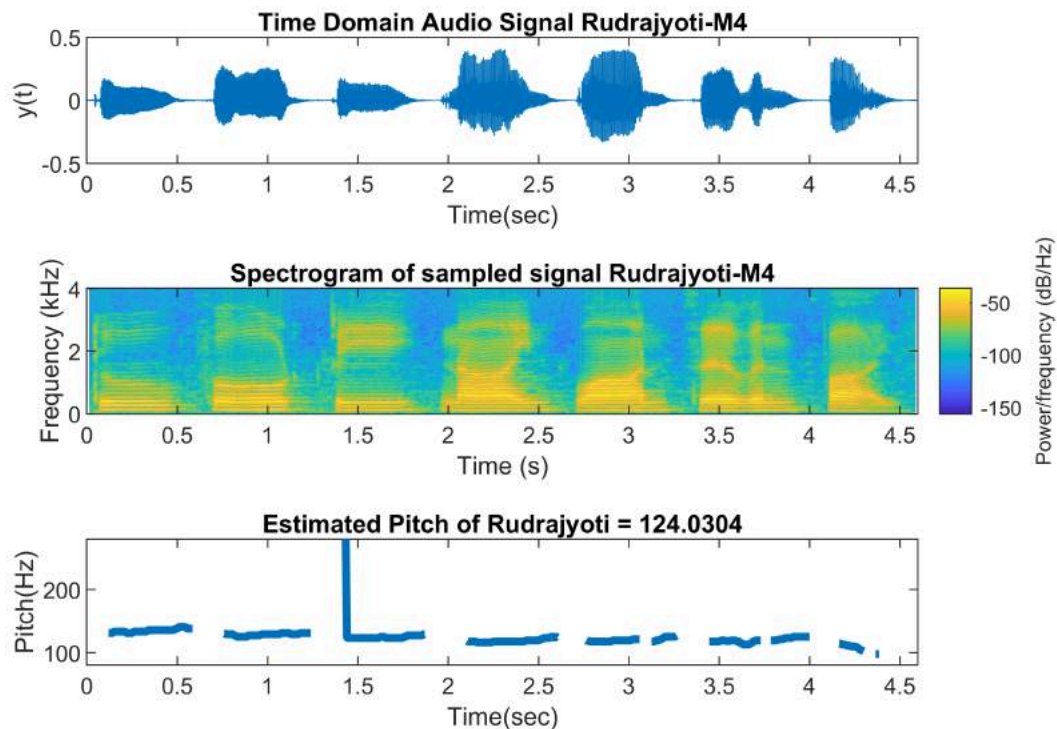


Fig: Speech Characteristics of Current Sample

Now reading lunch1.wav by Swarnava

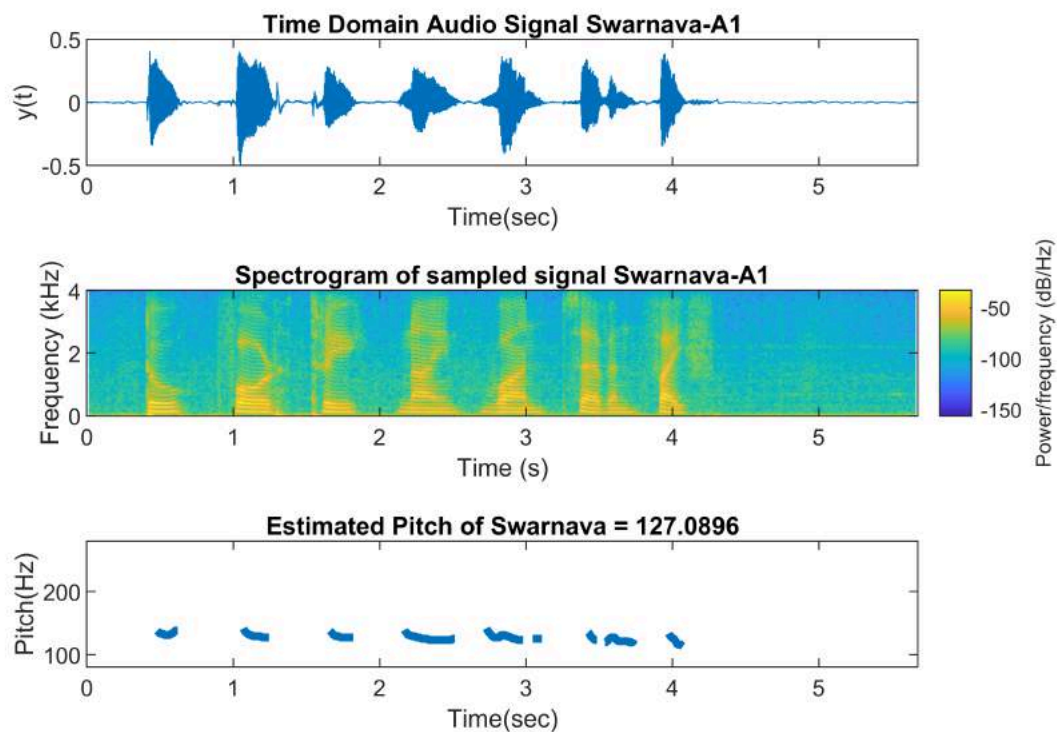


Fig: Speech Characteristics of Current Sample

Now reading lunch2.wav by Swarnava

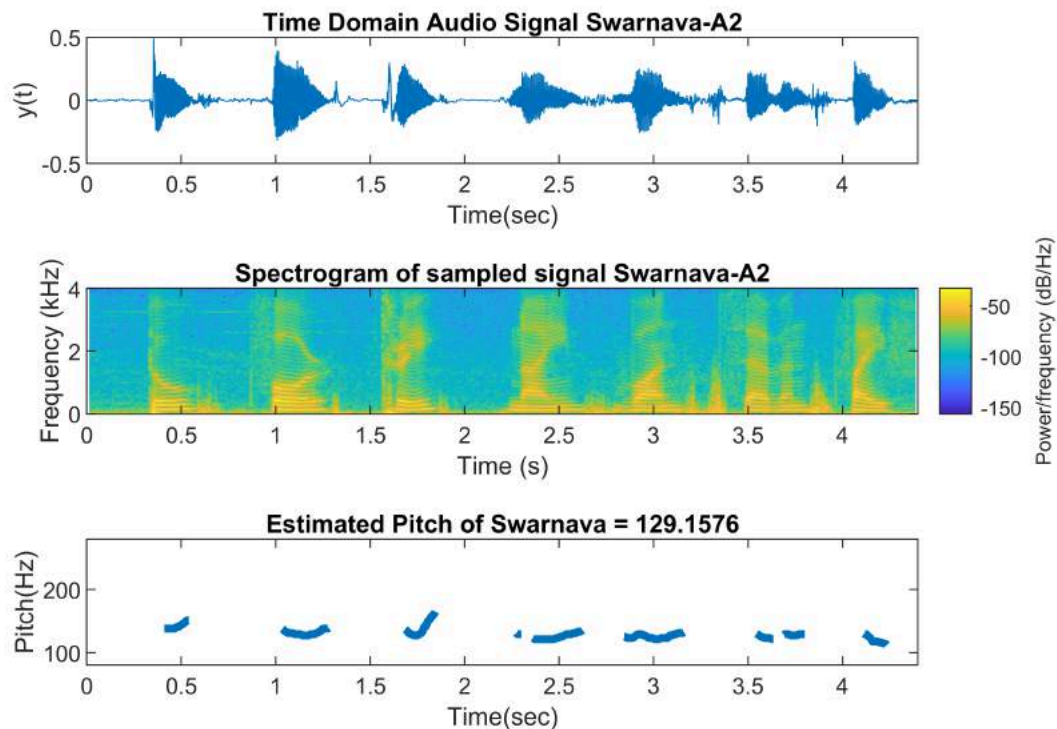


Fig: Speech Characteristics of Current Sample

Now reading lunch3.wav by Swarnava

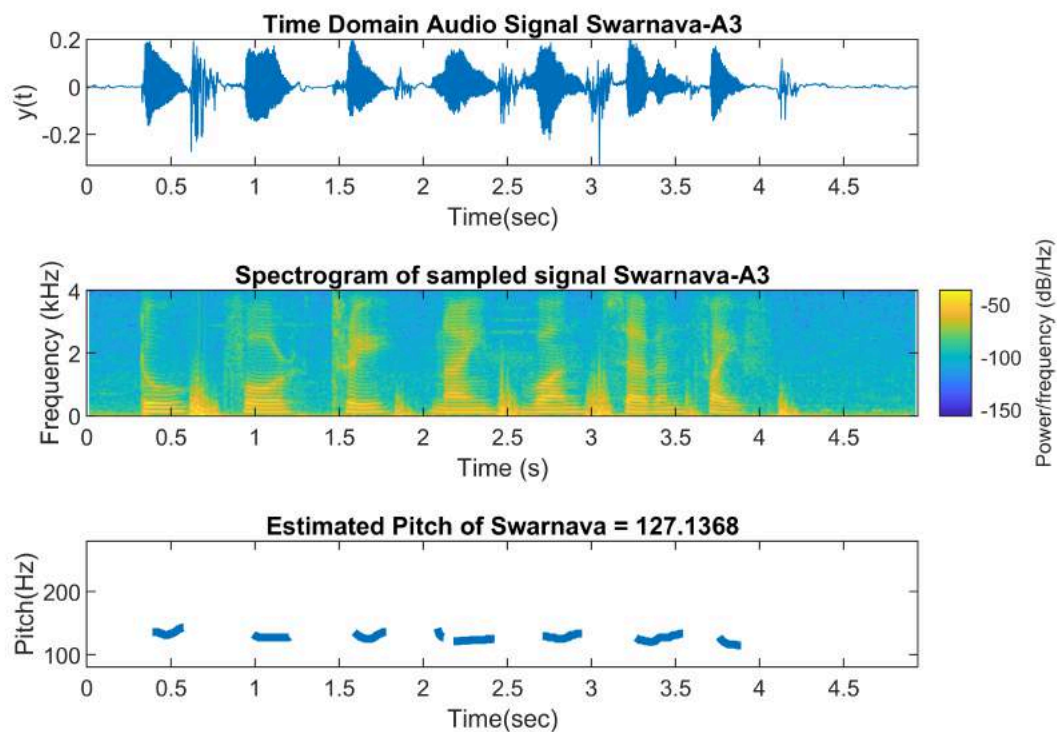


Fig: Speech Characteristics of Current Sample

Now reading lunch4.wav by Swarnava

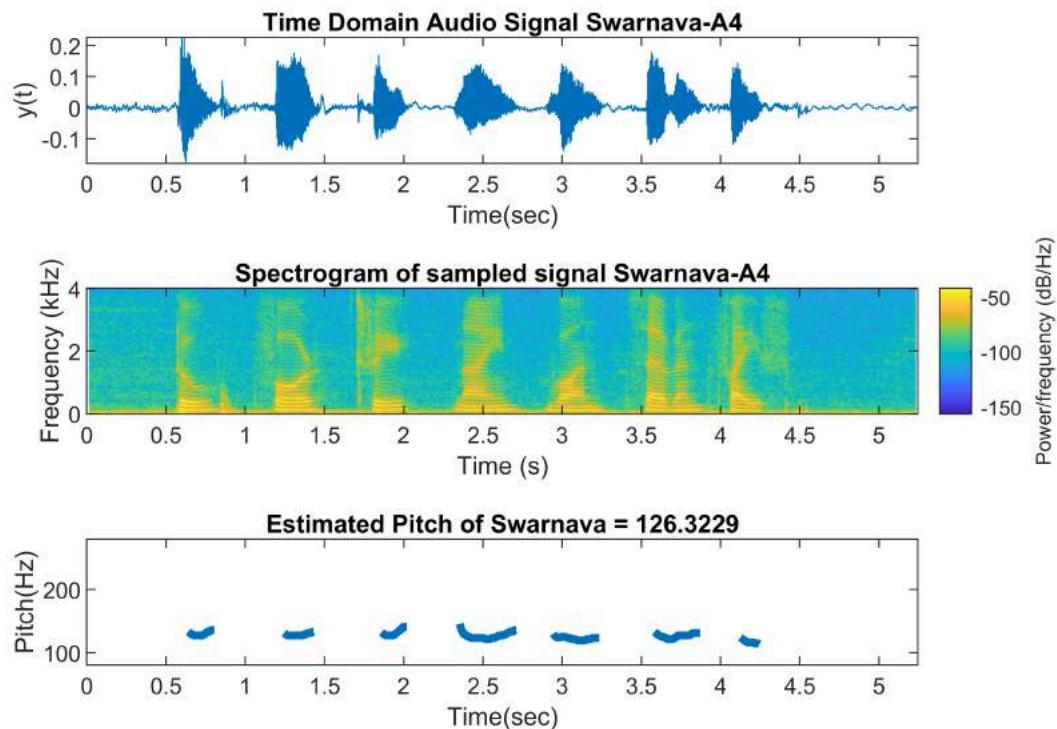


Fig: Speech Characteristics of Current Sample

Now reading morning1.wav by Swarnava

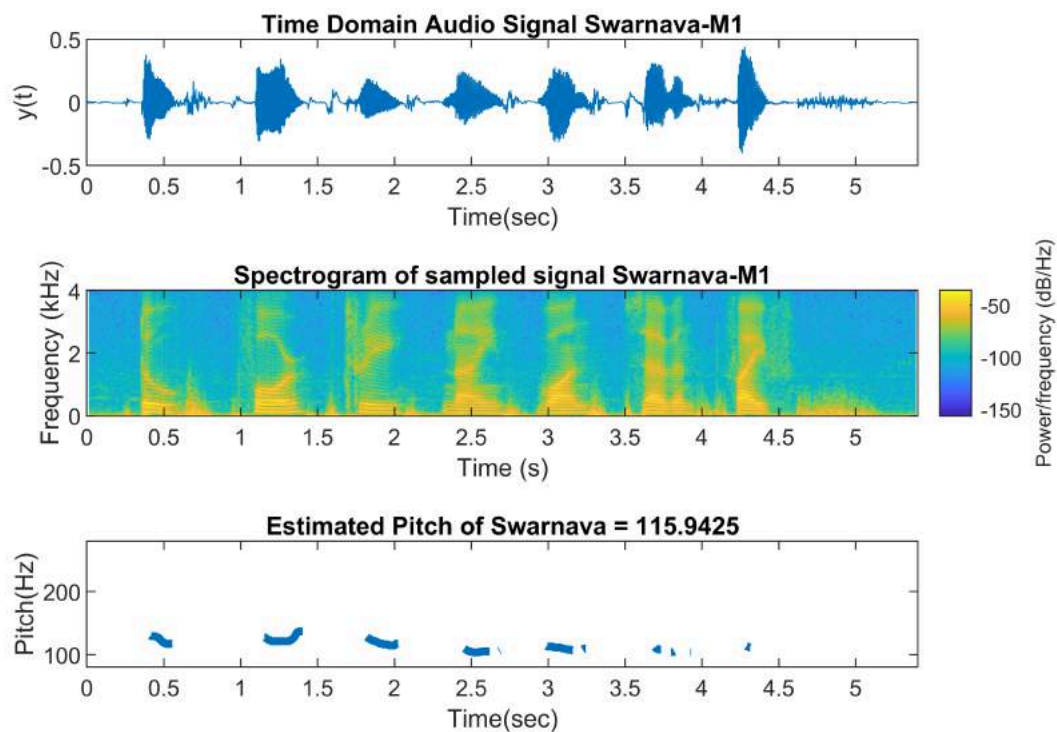


Fig: Speech Characteristics of Current Sample

Now reading morning2.wav by Swarnava

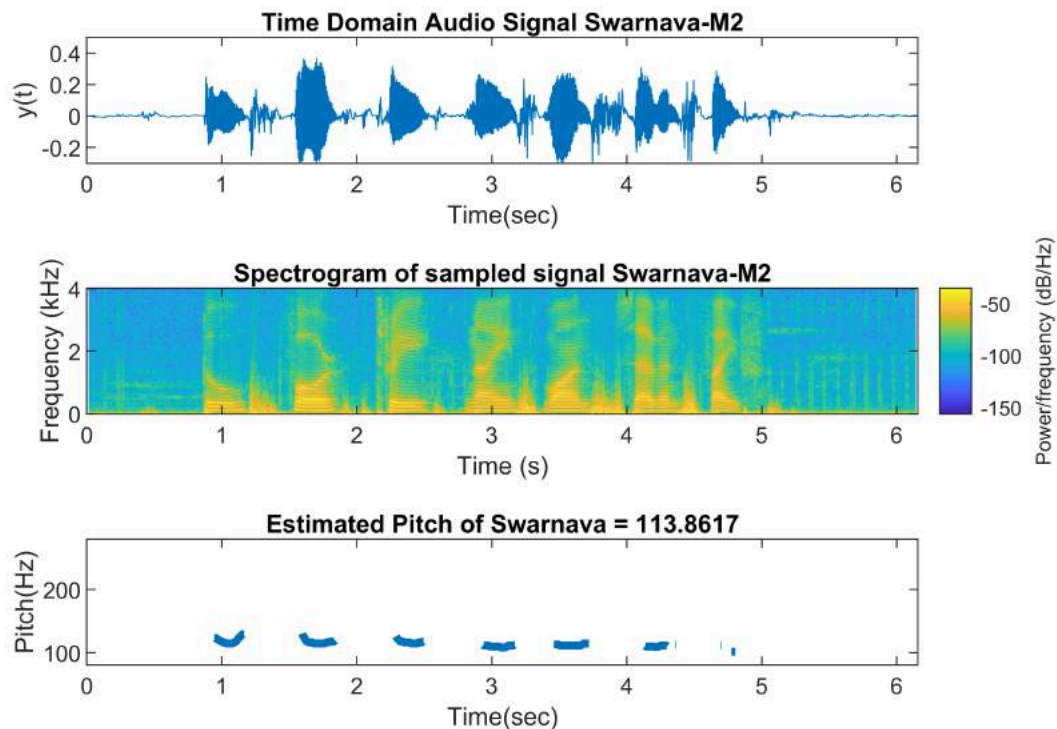


Fig: Speech Characteristics of Current Sample

Now reading morning3.wav by Swarnava

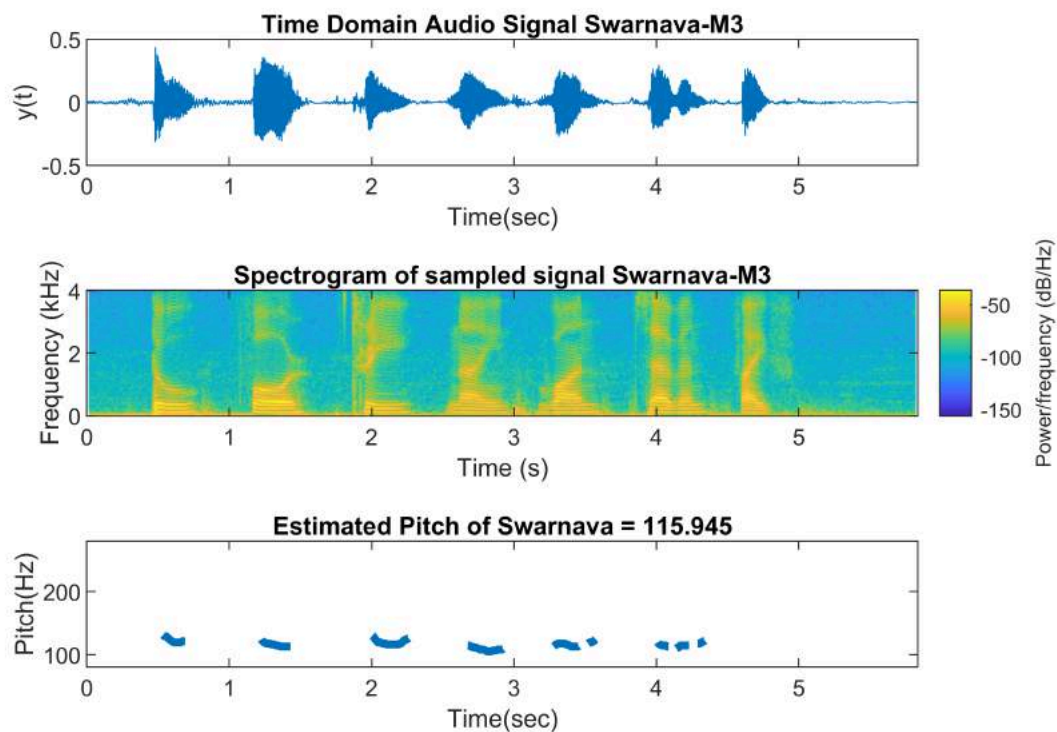


Fig: Speech Characteristics of Current Sample

Now reading morning4.wav by Swarnava

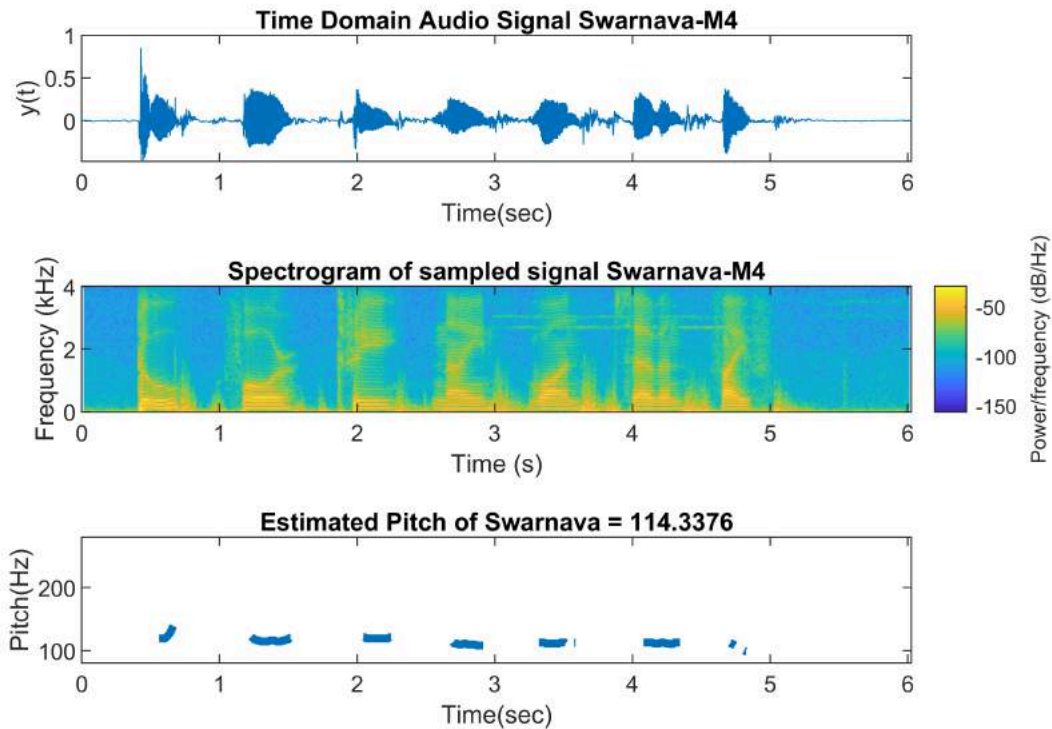


Fig: Speech Characteristics of Current Sample

```
fprintf(1, 'Reading Complete \n');
```

Reading Complete

```
%close all;

category = unique(ucat);
energy2 = zeros(length(category), Nfilters);

for i = 1:length(category)
    for k = 1:length(ucat)
        if(strcmp(ucat(k),category(i)))
            energy2(i,:) = energy2(i,:) + energy(k,:);
        end
    end
    energy2(i,:) = energy2(i,+)/max(energy2(i,:));
end
```

6) Computing Euclidean Distance and Heatmap

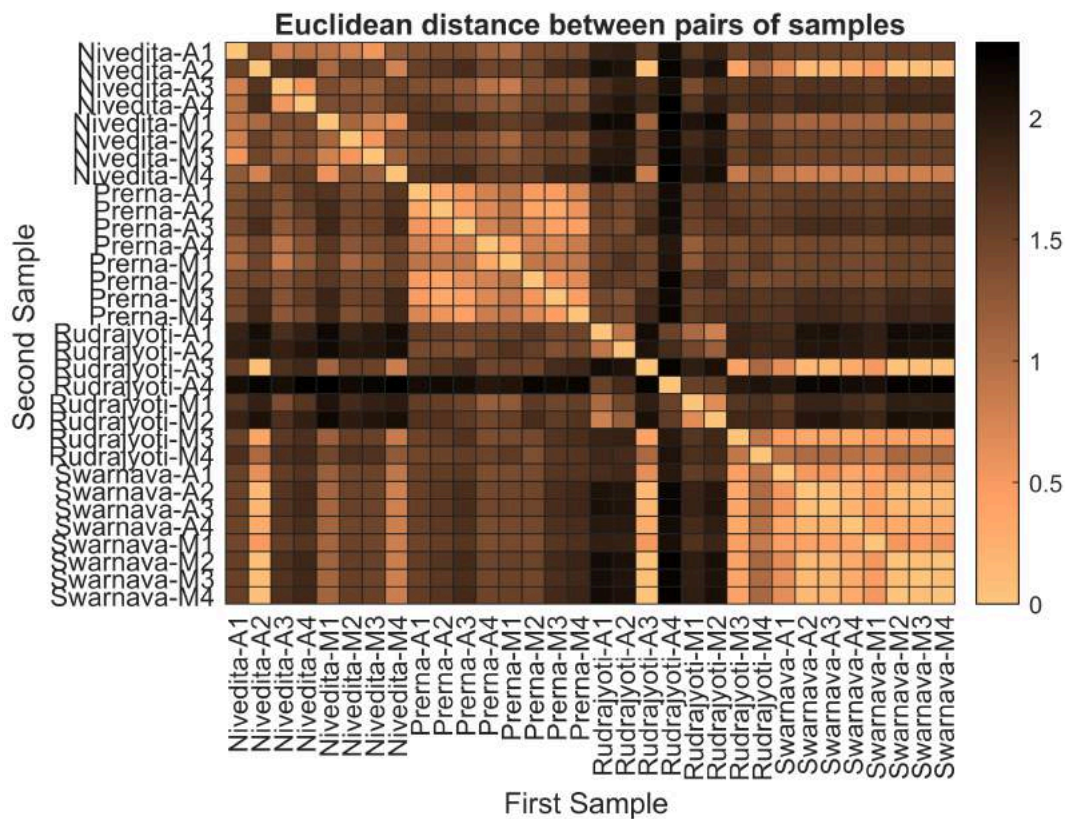
```
Y = pdist(energy); %Probability Distribution Matrix (Uses Euclidean Distance)
Y2 = pdist(energy2);

%Euclidean Distance Heatmap with all samples
figure
cmap = colormap('copper');
newcmap = flipud(cmap);
mat = squareform(Y);
```

```

heatmap(labels,labels,mat,'ColorMap',newcmap)
title('Euclidean distance between pairs of samples')
xlabel('First Sample ')
ylabel('Second Sample ')
saveas(gcf, "uniheatmap.png")

```



```

%Heatmap with 4 samples averaged
figure
heatmap(category,category,squareform(Y2),'ColorMap',newcmap)
title('Euclidean distance between pairs of Averaged Samples')
xlabel('First Averaged Sample ')
ylabel('Second Averaged Sample ')
saveas(gcf, "uniheatmapavg.png")

```

