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AMATH 482
March 6, 2020

HW4: Music Classification

Abstract

In this assignment, I was tasked with classifying 5 second music clips using singular value decomposition (SVD) and linear discriminant analysis (LDA). The three tests explored involved varying genres with set artists, varying artists with set genres, and varying genres with varying artists. This method of signal processing breaks down the music clips into their principle components and categorizes them based on variation in their components. In this paper, I exemplify the process for building an LDA algorithm, setting thresholds, and testing your algorithm. Ultimately, I obtained a correct categorization of 60%, which is far less than ideal, but still shows the power of this image processing technique.

Introduction

In this section, I will give a brief background to singular value decomposition (SVD) and linear discriminant analysis (LDA), which is discussed further throughout this paper. These image processing tools are used to simplify complex multidimensional systems into singular values which can be compared via LDA. SVD breaks down a given set of data to find which portions of the data holds the most variance and where is there redundancies. This allows for projections of the data on to these components that hold the most variance, which will reduce the size of the data set, but retain a majority of the information in the original data set. LDA takes this process one step further and analyzes the projections on to the principle components to find thresholds that distinguish different portions of the data. This is extremely useful for categorizing complex data sets without having to iterate and analyze the entirety of each piece of data in the complex data set. By reducing the amount of information needed for analysis and effective sorting, the computational effort is greatly reduced.

For this assignment, I generated data sets including 5 second clips of songs from different genres and artists. I then transformed these clips into spectrograms, reshaped the spectrogram arrays to make it 2 dimensional, and used MATLABs SVD command to reduce the data down to its singular values and principle components. Then I used LDA to set thresholds between the principle components to define regions that would correspond with specific genres of music or types of artists. After LDA, I was able to categorize new 5 second clips of music by projecting them on to the largest principle component and sorting based on the previously defined thresholds. Although this example of classification via SVD and LDA does not show the best accuracy (since genres and artists aren't confined to specific ranges of sound), LDA can be applied to many other systems including face recognition and machine learning.

Theoretical Background

This section will give more detail to the theory behind SVD and LDA, and how the combining these two data processing methods allows for categorizing of complex data sets. SVD has many applications, which have been explored in previous assignments (i.e. PCA and POD). The SVD method transforms each row in a given matrix of orthogonal data points into hyper-ellipses in order to break down the data and compare variance between recordings to find redundancies. A useful figure for visualizing the transform of the original matrix is shown below. Ultimately, the SVD breaks down the data by its total variance in each data set, which then can be rebuilt as a rank approximation, including less rows/columns compared to the original matrix.
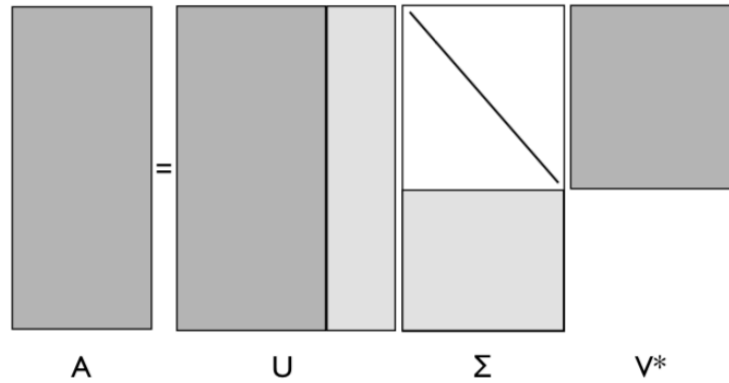
Figure 1: This figure shows a graphical representation of the relationships between outputs of the SVD (U,S,V) and the original matrix A.

From the SVD, we keep a limited number of features which dictates how many U columns and S*V' rows are used in future projections that recreates an approximation of the original data with less points. The amount of energy or strength captured in each projection can be shown by plotting the singular diagonal elements S. An example of this shown in the figure below. In this assignment, I chose 20 projections as a decent approximation of the original data because the energy decreased exponentially until around 20, where the decrease became more linear. Once the number of projections is chose, the last thing to do is the LDA to find thresholds that will divide the data and predict future data.
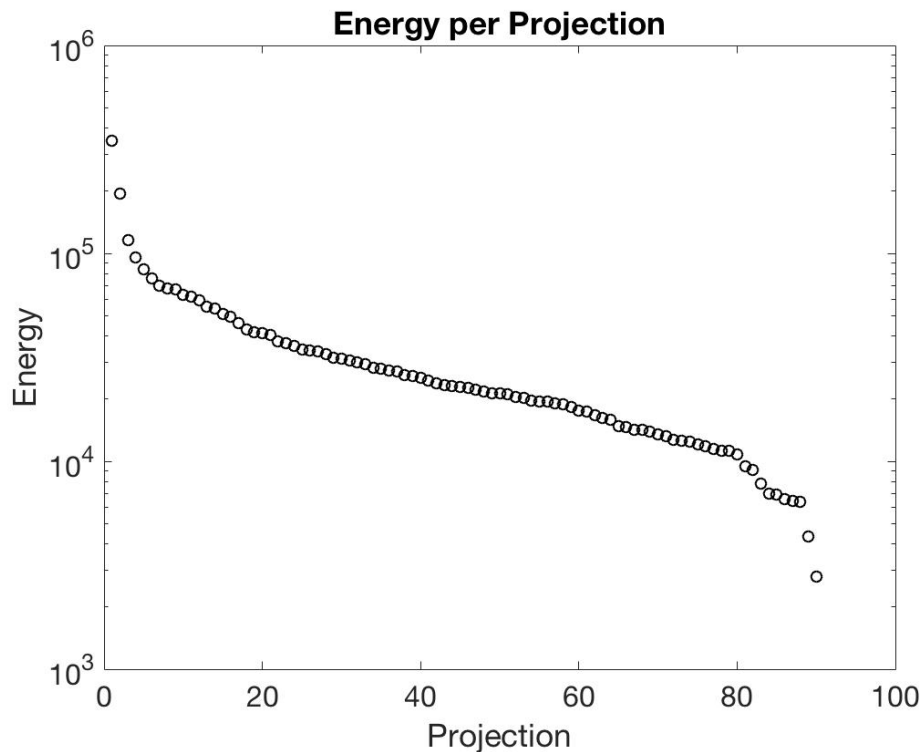

Figure 2: This figure shows an example of an energy plot verse the projection number after applying a singular value decomposition.

The goal of LDA is to find the best projection that will both maximize the distance between inter-class points and minimize the intra-class points. This summarizes to the equation shown below. The ideal LDA projection w is defined with S_B as the variance between classes

$$\mathbf{w} = \arg\max_{\mathbf{w}} \frac{\mathbf{w}^T \mathbf{S}_B \mathbf{w}}{\mathbf{w}^T \mathbf{S}_W \mathbf{w}}$$

and S_W as the variance within each class. The equations for S_B and S_W are shown below with "u" equal to the mean of all 3 projections, "u_i" equal to the mean of each in-class projection, and "x" representing each class of projection. With LDA we can now find the projection that will separate our data into classes that can be separated via some threshold.

$$S_B = \frac{1}{3} \sum_{i=1}^{3} (u_i - u)(u_i - u)'$$

$$S_W = \sum_{i=1}^{3} \sum_{x} (x - u_i)(x - u_i)'$$

Algorithm Implementation

This section will summarize the functions and methods used to calculate the SVD, LDA, determine the thresholds, and test the algorithm. First, I used the function "webread" to obtain my data sets from the Free Music Archive. I generated 5 seconds samples from the raw data. Then, I turned the those 5 second music samples into spectrograms with my function "specmaker." This process is shown in figure 3. However, the SVD only allows 2D inputs and I had 90 pages of 2 dimentional spectrograms. So I needed to flatten the spectrograms using reshape in a function I made called "specshaper." Now the data is ready for SVD and LDA.
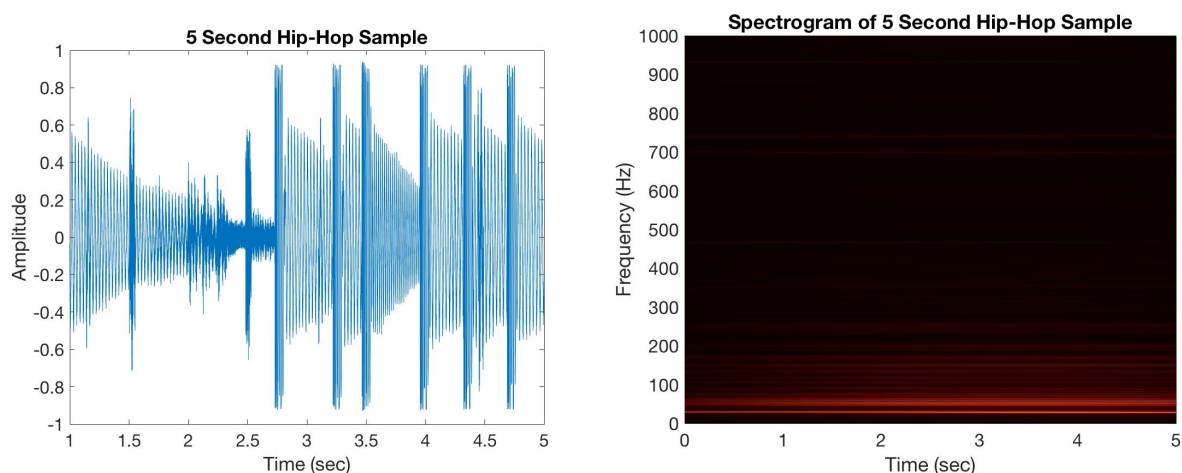

Figure 3: This figure shows an example of a 5 second hip-hop clip (left) and the corresponding spectrogram (right). This spectrogram will get flattened in order to be put into the SVD function.

Implementing the SVD is simple because MATLAB has a built in function "svd." I combined the SVD and LDA into one function called "music-trainer." This function did essentially what was explained in the previous section. It took the 20 features containing the most energy, projected the singular values, and found the projection that had the most variance between inter-class points and the least variance in intra-class points. For this assignment, finding a perfect threshold was difficult because the I often had high variation of one class compared to the other two, but low variation between the remaining classes. This made setting an accurate threshold between the remaining classes very difficult and resulted in most of the errors in this assignment. Therefore, I decided to set the two thresholds at the lowest and highest of the three class means.

To test the accuracy of the thresholds made from the LDA algorithm, I uploaded 90 new music clips that varied in genre and artist depending on the algorithm made. The process for generating the flattened spectrogram vectors is the same as before, but now instead of using SVD and LDA, I projected the data onto W projection and sorted the spectrograms based on the preset thresholds. I checked my accuracy using a function I made called "key."

Computational Results

This section will display the results from the three tests explored in this assignment. The three tests I explored, were varying genres with set artists, set genre with varying artists, and lastly varying genres with varying artists. Based on the process out lined earlier in the algorithm implementation section, I was able to obtain the training set projection that separated each class in each test type. Those projections are shown in figure 4. Then I also tested each algorithm with a new test data set, and a figure showing areas of high error verse low error is also shown in figure 4.

For the first test (varying genres with set artists), the training set projection did not seem to separate the rock and jazz samples very well, but the data is skewed because the hip-hop samples was separated very far away. The difference in means between the rock and jazz samples was actually near 500, which was far enough to obtain a decent classification. For test one, I obtained a 60% correct classification, which could have easily been higher if I increased the lower threshold to -20,000 shown in the test projection graph.

In the second test (set genres with varying artists), I chose the genre of country music because I believe all country music sounds the same. So I wanted to test if the algorithm could separate the artists correctly. Although the initial training set projection looked to have equal separation between each group, there was still a large amount of overlap between the groups, and as expected there are many wrong sortings in between the two thresholds. Understandably, sorting out artists within the same genre is very difficult because most artists have variation between all their songs, or else no one would listen. For the second test, I only obtained a correct classification percentage of 35%, which is only 2% higher than randomly guessing a class. Compared to the first test, the second test has far worse accuracy, but it is possible if the thresholds were moved in further, the accuracy could increase slightly.

Finally, in the last test (varying genres with varying artists), I expected to see similar results as test one because I expected genres to separate much easier than artists. However, I only obtained a correct classification 40% of the time. Based on the test set projections graph, it seems like the lower threshold could be higher, but strangely many of the projections are concentrating near the middle. I believe this might be because my training set was not diverse enough considering that many artists have varying interpretations of the same genre.
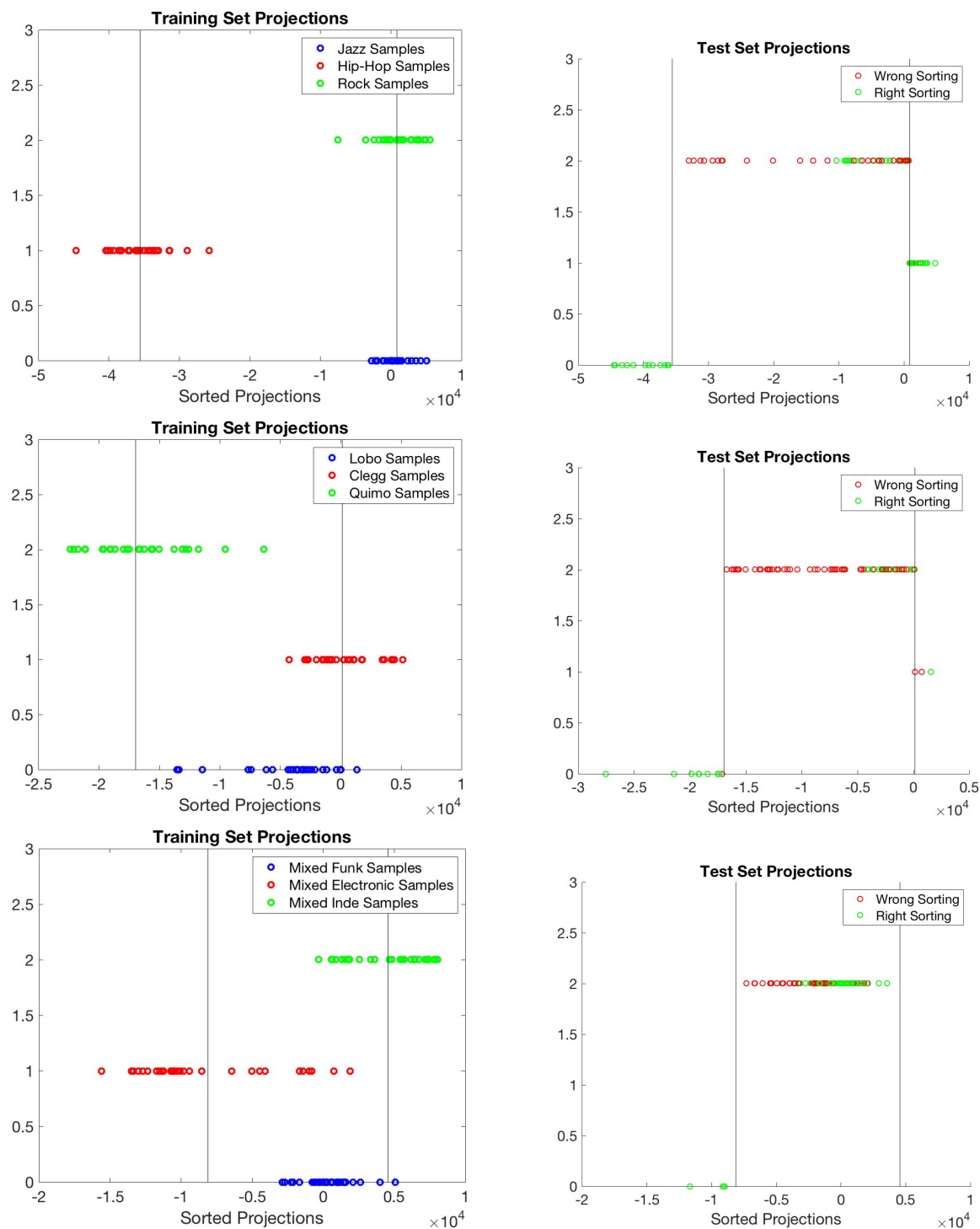
Figure 4: This figure shows the results of each training and test projections for each of the three test groups. The top is test 1, middle is test 2, and bottom is test 3. In the test set projections shown on the right, green circles show correct categorization and red circles shown incorrect categorization. For many of the test projections, it seems like the thresholds were set too wide, which means a different threshold setting parameter may lead to better categorization.

Conclusions

        In conclusion, the LDA algorithm test with varying genres and set artists resulted in the highest correct categorization. This is likely due to the fact that genres are much easier to classify compared to artists. Whenever the artists were the main source of variation in the test, the classification was poor because the variation between artists was difficult to quantify without a much larger data set for each artist. Nevertheless, LDA is an extremely powerful image processing too for classification of large complex data sets. Additionally, although this assignment only showed a correct categorization of 60%, there are other examples of LDA that, when fine-tuned better, have been shown to have correct categorization of around 95%. Furthermore, this method requires much less computing power compared to analyzing an entire original data set and sorting based on multiple complex thresholds.

Appendix A: Functions and & Explanations
- *Webread:* a command that takes a string input (url) and outputs the data from that url.
- *Resample:* takes a vector and will decrease the sampling of that vector.
- *Svd:* takes the SVD of a given set of data.

Appendix B: Code

```
%% Train 1 Training Samples
% Jazz Training Samples
close all; clear all; clc;
jazzurls = {'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_The_Lasso_of_Time.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_02_-_The_Other_Side_of_Darkness.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_Sleepless.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_07_-_Synchronicity.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_08_-_Gibraltar.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_In_Former_Rings.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_Uncertain.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_Played_by_Ear.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_13_-_Dust_and_Memories.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_14_-_Depressed_Buddhist.mp3'};
count = 1;
shrink = 5;
yjazz = zeros(5*(44100/shrink),length(jazzurls)*3);
```

```matlab
for  k = 1:length(jazzurls)
    [y,Fs] = webread(jazzurls{k});
    y = resample(y,1,shrink);
    Fs = Fs/shrink;
    yjazz(:,count) = y((Fs*5):(Fs*10-1),1);
    yjazz(:,count+1) = y((Fs*30):(Fs*35-1),1);
    yjazz(:,count+2) = y((Fs*60):(Fs*65-1),1);
    count = count + 3;
end

% Rock Training Samples
rockurls = {'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_01_-
_Out_of_School.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_02_-_FM.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_03_-
_Fireworks.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_04_-
_Storyteller.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_05_-
_Siesta.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_06_-
_Echoes.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_07_-
_Summercase.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_08_-
_Overdose.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_09_-
_So_Easy.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_10_-
_April_from_the_train.mp3'};
count = 1;
yrock = zeros(5*(44100/shrink),length(rockurls)*3);
for  k = 1:length(rockurls)
    [y,Fs] = webread(rockurls{k});
    y = resample(y,1,shrink);
    Fs = Fs/shrink;
    yrock(:,count) = y((Fs*30):(Fs*35-1),1);
    yrock(:,count+1) = y((Fs*60):(Fs*65-1),1);
    yrock(:,count+2) = y((Fs*120):(Fs*125-1),1);
    count = count + 3;
end

% Hip-Hop Training Sample
hipurls = {'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/August_2019/Yung_Kartz_-_05_-
_Picture_Perfect.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/August_2019/Yung_Kartz_-_04_-_One_Way.mp3'
```

```matlab
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/August_2019/Yung_Kartz_-_03_-_Intranet.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/August_2019/Yung_Kartz_-_02_-_Stranger.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/August_2019/Yung_Kartz_-_01_-_Jeopardy.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/July_2019/Yung_Kartz_-_08_-_Landline.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/July_2019/Yung_Kartz_-_07_-_Frontline.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/July_2019/Yung_Kartz_-_06_-_Psychedelic.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/July_2019/Yung_Kartz_-_05_-_Magic.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/July_2019/Yung_Kartz_-_04_-_Abandoned.mp3'};
count = 1;
yhip = zeros(5*(44100/shrink),length(hipurls)*3);
for  k = 1:length(hipurls)
    [y,Fs] = webread(hipurls{k});
    y = resample(y,1,shrink);
    Fs = Fs/shrink;
    yhip(:,count) = y((Fs*30):(Fs*35-1),1);
    yhip(:,count+1) = y((Fs*60):(Fs*65-1),1);
    yhip(:,count+2) = y((Fs*120):(Fs*125-1),1);
    count = count + 3;
end

%% Test 1
hipspec = zeros(51,5*(44100/shrink),30);
for i = 1:size(yhip,2)
    hipspec(:,:,i) = specmaker(yhip(:,i),Fs);
end
hipflat = specshaper(hipspec);

rockspec = zeros(51,5*(44100/shrink),30);
for i = 1:size(yrock,2)
    rockspec(:,:,i) = specmaker(yrock(:,i),Fs);
end
rockflat = specshaper(rockspec);

jazzspec = zeros(51,5*(44100/shrink),30);
for i = 1:size(yjazz,2)
    jazzspec(:,:,i) = specmaker(yjazz(:,i),Fs);
end
jazzflat = specshaper(jazzspec);

%%
features = 20;
[U,S,V,w,threshold1,threshold2,sortg1,sortg2,sortg3] = ...
music_trainer(jazzflat,hipflat,rockflat,features);
%%
p1 = plot(sortg1,zeros(30),'ob','Linewidth',2);
hold on
p2 = plot(sortg2,ones(30),'or','Linewidth',2);
p3 = plot(sortg3,2*ones(30),'og','Linewidth',2);
plot([threshold1,threshold1],[0,3],'k')
```

```matlab
plot([threshold2,threshold2],[0,3],'k')
ylim([0 3])
title('Training Set Projections')
xlabel('Sorted Projections')
legend([p1(1) p2(1) p3(1)],'Jazz Samples','Hip-Hop Samples','Rock Samples')
set(gca,'Fontsize',16)
% figure()
% semilogy(diag(S),'ko')
%%
close all;

tslide = 0:0.1:5;
k=(1/5)*[0:(length(yhip)/2-1) (-length(yhip)/2):-1];
thipmus = linspace(1,5,5*(44100/shrink));
figure()
plot(thipmus,yhip(:,5))
ylabel('Amplitude')
xlabel('Time (sec)')
title('5 Second Hip-Hop Sample')
set(gca,'Fontsize',16)
figure()
pcolor(tslide,fftshift(k),hipspec(:,:,5).');
shading interp
set(gca, 'Ylim',[0,1000], 'Fontsize',16)
colormap(hot)
ylabel('Frequency (Hz)')
xlabel('Time (sec)')
title('Spectrogram of 5 Second Hip-Hop Sample')


%% Test 1

testurls = {'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_11_-
_Riots.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_12_-_B-
Side.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_13_-
_Italia_90.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Jahzzar/Travellers_Guide_Excerpt/Jahzzar_-_14_-
_Before__After.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Music_for_Video/Jahzzar/The_Crowd_excerpt/Jahzzar_-_02_-
_Streetview.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/The_Crowd_excerpt/03_-_Car_Crash.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/The_Crowd_excerpt/04_-_Ice_Cream.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Music_for_Video/Jahzzar/The_Crowd_excerpt/Jahzzar_-_06_-
_Agoraphobia.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/The_Crowd_excerpt/07_-_Polaroid.mp3';
```

```
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Music_for_Video/Jahzzar/The_Crowd_excerpt/Jahzzar_-_08_-
_Bored.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/March_2019/Yung_Kartz_-_01_-_Number_One.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/March_2019/Yung_Kartz_-_02_-_Reward.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/March_2019/Yung_Kartz_-_03_-_Inbound.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/March_2019/Yung_Kartz_-_04_-_Out_Cold.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/March_2019/Yung_Kartz_-_15_-_OUTCAST.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/March_2019/Yung_Kartz_-_06_-_u_know.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/March_2019/Yung_Kartz_-_07_-_Bankroll.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/March_2019/Yung_Kartz_-_08_-
_Strange_Times.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/March_2019/Yung_Kartz_-_09_-_Made_It.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Yung_Kartz/March_2019/Yung_Kartz_-_10_-
_Crystalline.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_Uncertain.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_Played_by_Ear.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_13_-_Dust_and_Memories.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_14_-_Depressed_Buddhist.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_15_-_Turning.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_16_-_Dakota.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/The_Lasso_of_Time/17_-_Rain.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_22_-_Microwave.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_23_-_23_Wacko.mp3';
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Unheard_Music_Concepts/The_Lasso_of_Time/Unheard_Music_
Concepts_-_24_-_Cosmic_Relevance.mp3'};

count = 1;
ytest = zeros(5*(44100/shrink),length(testurls));
for  k = 1:length(testurls)
```

```matlab
        [y,~] = webread(testurls{k});
        Fs = 44100;
        y = resample(y,1,shrink);
        Fs = Fs/shrink;
        ytest(:,count) = y((Fs*15):(Fs*20-1),1);
        ytest(:,count+1) = y((Fs*30):(Fs*35-1),1);
        ytest(:,count+2) = y((Fs*50):(Fs*55-1),1);
        count = count + 3;
end
%%
testspec = zeros(51,5*(44100/shrink),30);
for i = 1:size(ytest,2)
    testspec(:,:,i) = specmaker(ytest(:,i),Fs);
end
testflat = specshaper(testspec);

Testmat = U'*testflat;
pval = w'*Testmat;
ansvec = zeros(1,90);
for i = 1:length(pval)
    if pval(i)<threshold1
        ansvec(i) = 1; %hip
    elseif pval(i)>threshold2
        ansvec(i) = 2; %jazz
    else
        ansvec(i) = 3; %rock
    end
end
keyvec = [3*ones(1,30) ones(1,30) 2*ones(1,30)];
ernum = key(ansvec,keyvec);
percentcorrect1 = (1-sum(ernum)/90)*100
%%
for i = 1:length(ernum)
    hold on
    if ernum(i) == 1
        pwrong = plot(pval(i),ansvec(i)-1,'ro');
    else
        pright = plot(pval(i),ansvec(i)-1,'go');
    end
end
% plot(pval,ernum,'ko')
plot([threshold1,threshold1],[0,3],'k')
plot([threshold2,threshold2],[0,3],'k')
legend([pwrong(1) pright(1)],'Wrong Sorting','Right Sorting')
set(gca,'Fontsize',16)
title('Test Set Projections')
xlabel('Sorted Projections')

%% Train 2 Training Samples
clear all; close all; clc;
train2urls = {'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_01_-_Indian_Summer_ID_206.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_02_-_Jonny_pass_auf_ID_290.mp3'
```

```
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_03_-_Cabanossi_Mwe_ID_258.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_04_-_Nighlight_ID_202.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_05_-_Out_of_Paradise_ID_246.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_06_-_Swinging_Sofas_ID_272.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_07_-_Echoes_Boogie_Dancehall_ID_278.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_08_-_Springtime_ID_277.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_09_-_Pianoman_Sofa_ID_265.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_10_-_Ja_was_sah_ich_da_ID_247.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_01_-
_The_Way_I_Feel.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_02_-
_Our_Love_Is_Rich_Enough.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_03_-_Peculiar.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_04_-_Is_Real.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_05_-
_It_Aint_This_Bed.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_06_-
_Help_Desk.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_07_-
_Working_For_The_County.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_08_-
_Life_and_Times.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_09_-_My_Word.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_10_-_Selfish.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_01_-
_Jai_t_au_bal.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_02_-
_Quand_la_bire_est_tire.mp3'
```

```matlab
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_03_-
_Un_gars_de_la_baie.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_04_-
_La_ballade_de_Jacques_Cartier.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_05_-
_John_Junior.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_06_-
_John_Edmond.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_07_-
_Ici_en_Gaspsie.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_08_-
_Toute_la_nuit.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_09_-_Mama.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_10_-
_Le_pcheur.mp3'};
shrink = 5;
count = 1;
ytrain2 = zeros(5*(44100/shrink),length(train2urls));
for  k = 1:length(train2urls)
    [y,~] = webread(train2urls{k});
    Fs = 44100;
    y = resample(y,1,shrink);
    Fs = Fs/shrink;
    ytrain2(:,count) = y((Fs*15):(Fs*20-1),1);
    ytrain2(:,count+1) = y((Fs*30):(Fs*35-1),1);
    ytrain2(:,count+2) = y((Fs*50):(Fs*55-1),1);
    count = count + 3;
end
%%
train2spec = zeros(51,5*(44100/shrink),30);
for i = 1:size(ytrain2,2)
   train2spec(:,:,i) = specmaker(ytrain2(:,i),Fs);
end
train2flat = specshaper(train2spec);
%%
features = 20;
[U,S,V,w,threshold1,threshold2,sortg1,sortg2,sortg3] = 
music_trainer(train2flat(:,1:30),train2flat(:,31:60),train2flat(:,61:90),feat
ures);
%%
p1 = plot(sortg1,zeros(30),'ob','Linewidth',2);
hold on
p2 = plot(sortg2,ones(30),'or','Linewidth',2);
p3 = plot(sortg3,2*ones(30),'og','Linewidth',2);
plot([threshold1,threshold1],[0,3],'k')
plot([threshold2,threshold2],[0,3],'k')
ylim([0 3])
title('Training Set Projections')
xlabel('Sorted Projections')
legend([p1(1) p2(1) p3(1)],'Lobo Samples','Clegg Samples','Quimo Samples')
```

```matlab
set(gca,'Fontsize',16)
%% Test 2
testurls = {'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_11_-_ICE_Meltdown_ID_251.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_12_-_Cant_Let_Her_Go_ID_261.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_13_-_Mary_Roose_Spaceblues_ID_94.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Lobo_Loco/My_FAVORITE_SWEET_HOME_TRACKS/Lobo_Loco_-
_14_-_Buzzard_ID_177.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Lobo_Loco/Adventure/Lobo_Loco_-_01_-
_Blues_about_Mary_Roose_ID_1153.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Lobo_Loco/Adventure/Lobo_Loco_-_02_-
_Traveling_to_Lousiana_-_Soft_Delay_ID_1174.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Lobo_Loco/Adventure/Lobo_Loco_-_03_-
_Cool_and_Wonderful_ID_1163.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Lobo_Loco/Adventure/Lobo_Loco_-_04_-
_Bad_Old_Daemons_ID_1138.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Lobo_Loco/Adventure/Lobo_Loco_-_05_-
_Evening_Campfire_ID_1178.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Lobo_Loco/Adventure/Lobo_Loco_-_06_-
_Snowflakes_ID_1139.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_11_-
_Good_Graces.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_12_-
_Bed_of_Weeds.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_13_-
_Unfair_To_Me.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_14_-
_I_Have_You.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Derek_Clegg/Good_Graces/Derek_Clegg_-_15_-
_Never_Really_Change.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/blocSonic/Derek_Clegg/Overlook_The_Human_Race_5_Year_Anniversary_Re
-Release/Derek_Clegg_-_01_-_To_Lose_You.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/blocSonic/Derek_Clegg/Overlook_The_Human_Race_5_Year_Anniversary_Re
-Release/Derek_Clegg_-_02_-_Never_Leave_LA.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/blocSonic/Derek_Clegg/Overlook_The_Human_Race_5_Year_Anniversary_Re
-Release/Derek_Clegg_-_03_-_If_Only_We_Had_More_Time.mp3'
```

```matlab
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/blocSonic/Derek_Clegg/Overlook_The_Human_Race_5_Year_Anniversary_Re
-Release/Derek_Clegg_-_04_-_Photograph.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/blocSonic/Derek_Clegg/Overlook_The_Human_Race_5_Year_Anniversary_Re
-Release/Derek_Clegg_-_05_-_Carry_On.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_11_-
_Tite_tuque__Bosco_Stomp_.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_12_-
_Capitaine_Jack.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_13_-
_Ma_bouteille.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_14_-
_Loin_devant.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_15_-
_Su_lquai.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_16_-
_Mother.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_17_-
_Matelot.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_18_-
_Le_chasseur.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_19_-
_Le_train_pour_Paspbiac.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Quimorucru/Un_mchant_party/Quimorucru_-_20_-
_Salut_John.mp3'};
count = 1;
ytest = zeros(5*(44100/shrink),length(testurls));
for  k = 1:length(testurls)
    [y,~] = webread(testurls{k});
    Fs = 44100;
    y = resample(y,1,shrink);
    Fs = Fs/shrink;
    ytest(:,count) = y((Fs*15):(Fs*20-1),1);
    ytest(:,count+1) = y((Fs*30):(Fs*35-1),1);
    ytest(:,count+2) = y((Fs*50):(Fs*55-1),1);
    count = count + 3;
end

%%
testspec = zeros(51,5*(44100/shrink),30);
for i = 1:size(ytest,2)
    testspec(:,:,i) = specmaker(ytest(:,i),Fs);
end
testflat = specshaper(testspec);

Testmat = U'*testflat;
pval = w'*Testmat;
```

```matlab
ansvec = zeros(1,90);
for i = 1:length(pval)
    if pval(i)<threshold2
        ansvec(i) = 1; %quimo
    elseif pval(i)>threshold1
        ansvec(i) = 2; %clegg
    else
        ansvec(i) = 3; %lobo
    end
end
keyvec = [3*ones(1,30) 2*ones(1,30) ones(1,30)];
ernum = key(ansvec,keyvec);
percentcorrect2 = (1-sum(ernum)/90)*100
%%
for i = 1:length(ernum)
    hold on
    if ernum(i) == 1
        pwrong = plot(pval(i),ansvec(i)-1,'ro');
    else
        pright = plot(pval(i),ansvec(i)-1,'go');
    end
end
% plot(pval,ernum,'ko')
plot([threshold1,threshold1],[0,3],'k')
plot([threshold2,threshold2],[0,3],'k')
legend([pwrong(1) pright(1)],'Wrong Sorting','Right Sorting')
set(gca,'Fontsize',16)
title('Test Set Projections')
xlabel('Sorted Projections')
%% Train 3 Training Samples
close all; clear all; clc
train3urls = {'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/KieLoKaz/Free_Ganymed/KieLoKaz_-_07_-
_Alte_Herren_Kielokaz_ID_364.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Checkie_Brown/hey/Checkie_Brown_-_10_-
_Violence_CB_34.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/KBOO/shane_br/Live_at_KBOO_for_The_Monday_Sampler_Nov_21_2016/shane
_br_-_01_-_Shane_Brown-Novem_2016-LIVE.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Lobo_Loco/Diversity_of_Life/Lobo_Loco_-_01_-
_Aldebaraner_Funky_Disco_ID_1126.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/KBOO/joyt/Live_at_KBOO_for_The_Monday_Sampler_02202017/joyt_-_01_-
_Joytribe-Feb_2017-LIVE.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/KBOO/dubio/Live_at_KBOO_for_The_Monday_Sampler_03202017/dubio_-
_01_-_Dubious_Move-Mar_2017-LIVE.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/KBOO/far_out/Live_at_KBOO_for_Grateful_Dead__Friends_07292017/far_o
ut_-_01_-_Far_Out_West-Jul_2017-LIVE.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/KBOO/worlds/Live_at_KBOO_for_Grateful_Dead__Friends_04152017/worlds
_-_01_-_Worlds_Finest-Apr_2017-LIVE.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/KBOO/radio_phone/Live_at_KBOO_for_The_Monday_Sampler_04102017/radio
_phone_-_01_-_Radio_Phoenix-Apr_2017-LIVE.mp3'
```

```
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/The_Gays/THE_AGENDA/The_Gays_-_09_-_Our_World.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/White_Market_Podcast/Six_Umbrellas/Private_Ark/Six_Umbrellas_-_09_-
_Longest_Summer.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/WFMU/Opra_Mort/Je_Suis_Parmi_Les_Cinq_Cents_Personnes_Que_Tu_Prfres
_Au_Monde/Opra_Mort_-_02_-_Les_Instants_Chavirs_Montreuil_19122009.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Synapsis/Goan_Psynapsia/Synapsis_-_06_-
_Goan_Toca_Me.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/C_C/Impendulo/C_C_-_01_-_UKUZIJABULISA.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/none_given/Sro/Sro_-_Singles/Sro_-
_Submersed_Phonics_JBYo_Collab.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Toucan_Music/Psychadelik_Pedestrian/Best_Bytes_Volume_4/Psychadelik
_Pedestrian_-_01_-_Drones.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/chZ_/The_Clones_of_Dr_Funkenstein/chZ__-_08_-
_Organ_Grinder_Swing.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Studio_11_Chicago/Glass_Lux/Glass_Lux_-_Singles/Glass_Lux_-
_Im_A_Machine.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Spiedkiks/Little_Smartphone_People/Spiedkiks_-_16_-
_Mos_Eisley_Cantina.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/tozo/albatross/tozo_-_15_-_ikarus.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Scott_Holmes/Inspiring__Upbeat_Music/Scott_Holmes_-_04_-
_Upbeat_Party.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/West_Cortez_Records/David_Hilowitz/Gradual_Sunrise/David_Hilowitz_-
_Gradual_Sunrise.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Mild_Wild/a_Queens_Lodge_b_Crooked_Straight/Mild_Wild_-
_02_-_Crooked_Straight.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Aglow_Hollow/Proximate_Laws_Baba_Yaga_Booty_Calls/Aglow
_Hollow_-_04_-_Dog_Soldier___Stand_Down.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Small_Tall_Order/B_Sides/Small_Tall_Order_-_02_-
_My_Fault.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/yumenoma/Instant_0_in_the_Universe/yumenoma_-_02_-
_____-_who_built_the_moon__-.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Pistol_Jazz/Chic/Pistol_Jazz_-_Winter_Snow.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Ryan_Andersen/Never_Sleep_-_Indie_Rock/Ryan_Andersen_-
_Well_Never_Sleep.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/The_Inventors/Counting_backwards/The_Inventors_-_09_-
_Blood_Milk.mp3'
```

```matlab
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/HealthBeauty/It_was_almost_certainly_a_small_child/Hea
lthBeauty_-_07_-_deathxmas.mp3'};

shrink = 5;
count = 1;
ytrain3 = zeros(5*(44100/shrink),length(train3urls));
for  k = 1:length(train3urls)
    [y,~] = webread(train3urls{k});
    Fs = 44100;
    y = resample(y,1,shrink);
    Fs = Fs/shrink;
    ytrain3(:,count) = y((Fs*15):(Fs*20-1),1);
    ytrain3(:,count+1) = y((Fs*30):(Fs*35-1),1);
    ytrain3(:,count+2) = y((Fs*50):(Fs*55-1),1);
    count = count + 3;
end
%%
train3spec = zeros(51,5*(44100/shrink),30);
for i = 1:size(ytrain3,2)
    train3spec(:,:,i) = specmaker(ytrain3(:,i),Fs);
end
train3flat = specshaper(train3spec);
%%
features = 20;
[U,S,V,w,threshold1,threshold2,sortg1,sortg2,sortg3] =
music_trainer(train3flat(:,1:30),train3flat(:,31:60),train3flat(:,61:90),feat
ures);
%%
p1 = plot(sortg1,zeros(30),'ob','Linewidth',2);
hold on
p2 = plot(sortg2,ones(30),'or','Linewidth',2);
p3 = plot(sortg3,2*ones(30),'og','Linewidth',2);
plot([threshold1,threshold1],[0,3],'k')
plot([threshold2,threshold2],[0,3],'k')
ylim([0 3])
title('Training Set Projections')
xlabel('Sorted Projections')
legend([p1(1) p2(1) p3(1)],'Mixed Funk Samples','Mixed Electronic
Samples','Mixed Inde Samples')
set(gca,'Fontsize',16)

%% Test 3
testurls = {'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Checkie_Brown/hey/Checkie_Brown_-_08_-_Hippie_Bulle_-
Stoned_Funghi_CB_28.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/KBOO/shane_brow/Live_at_KBOO_for_The_Monday_Sampler_11212016/shane_
brow_-_01_-_Shane_Brown-Nov_2016-LIVE.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Lobo_Loco/Diversity_of_Life/Lobo_Loco_-_02_-
_Autumn_Morning_ID_1022.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/KieLoKaz/Under_Stars/KieLoKaz_-_01_-
_End_of_Schwindel_ID_352.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/KieLoBot/Hounds_of_Darkmoor/KieLoBot_-_09_-
_Seniorita_K_ID_28.mp3'
```

```
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/The_Gays/THE_AGENDA/The_Gays_-_08_-_Wrong_.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/Ava_Luna/Services_EP/Ava_Luna_-_04_-
_Eight_Nine_Wont_You_Be_Mine.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/KBOO/Sweet_N/Live_at_KBOO_for_Lighthouse_Lessons_3212018/Sweet_N_-
_07_-_Sweet_N_Juicy-Irresistable-Mar_2018-LIVE.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Glad_Rags/Wonder_Under/Glad_Rags_-_08_-
_Social_Kapital_Reprise.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Macchiato_Funky/Bugella_20-50/Macchiato_Funky_-_09_-
_Ramona.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/White_Market_Podcast/Six_Umbrellas/Private_Ark/Six_Umbrellas_-_08_-
_Stockholm.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/WFMU/Opra_Mort/Je_Suis_Parmi_Les_Cinq_Cents_Personnes_Que_Tu_Prfres
_Au_Monde/Opra_Mort_-_01_-_La_Suite_Paris_01022010.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Synapsis/Goan_Psynapsia/Synapsis_-_05_-_Seven.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/C_C/Impendulo/C_C_-_02_-_TINTINABUL.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/chZ_/The_Clones_of_Dr_Funkenstein/chZ__-_07_-_Trash-A-
Go-Go.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Spiedkiks/Little_Smartphone_People/Spiedkiks_-_14_-
_Helicopter.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/tozo/albatross/tozo_-_14_-_wobble.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/blocSonic/Flex_Vector/The_Killbots_Are_Coming/Flex_Vector_-
_The_Killbots_Are_Coming.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Cock_Rock_Disco/Debmaster/Crevin/Debmaster_-_16_-
_Retourn_Acrobatique.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/WFMU/Smersh/Smersh_Library_Sampler/Smersh_-_15_-
_My_God_Those_Legs.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Scott_Holmes/Inspiring__Upbeat_Music/Scott_Holmes_-_01_-
_Storybook.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Mild_W/a_Queens_Lodge_b_Crooked_Straight/Mild_W_-_01_-
_Queens_Lodge.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/B_Sides/01_-_Until_We_Get_By.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/yumenoma/Instant_0_in_the_Universe/yumenoma_-_01_-
_____-_instant_0_in_the_universe_-.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/Pistol_Jazz/Chic/Pistol_Jazz_-_Swallow.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/no_curator/REW/Swimming_with_Kawatora/REW_-_01_-
_Swimming_With_Kawatora.mp3'
```

```matlab
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/Ryan_Andersen/Never_Sleep_-_Indie_Rock/Ryan_Andersen_-
_SLOW_FUZZ.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/The_Inventors/Counting_backwards/The_Inventors_-_12_-
_Brooklyn.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/Ziklibrenbib/HealthBeauty/It_was_almost_certainly_a_small_child/Hea
lthBeauty_-_08_-_the_pig__the_worm_devastate_the_overground.mp3'
    'https://files.freemusicarchive.org/storage-freemusicarchive-
org/music/ccCommunity/eddy/2_Damn_Loud/eddy_-_03_-_All_The_Way_Up.mp3'};
count = 1;
ytest = zeros(5*(44100/shrink),length(testurls));
for  k = 1:length(testurls)
    [y,~] = webread(testurls{k});
    Fs = 44100;
    y = resample(y,1,shrink);
    Fs = Fs/shrink;
    ytest(:,count) = y((Fs*15):(Fs*20-1),1);
    ytest(:,count+1) = y((Fs*30):(Fs*35-1),1);
    ytest(:,count+2) = y((Fs*50):(Fs*55-1),1);
    count = count + 3;
end


%%
testspec = zeros(51,5*(44100/shrink),30);
for i = 1:size(ytest,2)
   testspec(:,:,i) = specmaker(ytest(:,i),Fs);
end
testflat = specshaper(testspec);

Testmat = U'*testflat;
pval = w'*Testmat;
ansvec = zeros(1,90);
for i = 1:length(pval)
    if pval(i)<threshold1
       ansvec(i) = 1; %tech
    elseif pval(i)>threshold2
        ansvec(i) = 2; %funk
    else
        ansvec(i) = 3; %inde
    end
end
keyvec = [2*ones(1,30) ones(1,30) 3*ones(1,30)];
ernum = key(ansvec,keyvec);
percentcorrect3 = (1-sum(ernum)/90)*100
%%
for i = 1:length(ernum)
    hold on
    if ernum(i) == 1
        pwrong = plot(pval(i),ansvec(i)-1,'ro');
    else
        pright = plot(pval(i),ansvec(i)-1,'go');
    end
end
% plot(pval,ernum,'ko')
plot([threshold1,threshold1],[0,3],'k')
plot([threshold2,threshold2],[0,3],'k')
```

```matlab
legend([pwrong(1) pright(1)],'Wrong Sorting','Right Sorting')
set(gca,'Fontsize',16)
xlim([-2*10^4 10^4])
title('Test Set Projections')
xlabel('Sorted Projections')
%% Functions
function [Sgt_spec] = specmaker(yhip,Fs)
    a = 0.1;
    tslide = 0:0.1:5;
    thip = (1:length(yhip))/Fs;
    Sgt_spec = zeros(length(tslide),length(yhip));
    for j=1:length(tslide)
        g=exp(-a*(thip-tslide(j)).^2);
        Sg=g.*yhip(:,1)';
        Sgt=fft(Sg);
%         [~,tin]=max(abs(Sgt));
%         Sgtf = Sgt.*exp(-0.01*(k-k(tin)).^2);
        Sgt_spec(j,:) = fftshift(abs(Sgt));
    end
end

function [Spec_data] = specshaper(Sgt_spec)
    [m,n,p] = size(Sgt_spec);
    Spec_data = zeros(m*n,p);
    for k = 1:p
        Spec_data(:,k) = reshape(Sgt_spec(:,:,k),m*n,1);
    end
end

function [ernum] = key(ansvec,keyvec)
    ernum = zeros(1,90);
    for k = 1:length(ansvec)
        if ansvec(k) == keyvec(k)
            ernum(k) = 0;
        else
            ernum(k) = 1;
        end
    end
end

function [U,S,V,w,threshold1,threshold2,sortg1,sortg2,sortg3] = ...
music_trainer(genre1,genre2,genre3,feature)
    n1 = size(genre1,2);
    n2 = size(genre2,2);
    n3 = size(genre3,2);
    [U,S,V] = svd([genre1 genre2 genre3],'econ');

    music = S*V'; % projection onto principal components
    U = U(:,1:feature);
    prog1 = music(1:feature,1:n1);
    prog2 = music(1:feature,n1+1:2*n1);
    prog3 = music(1:feature,2*n1+1:3*n1);

    m1 = mean(prog1,2);
    m2 = mean(prog2,2);
    m3 = mean(prog3,2);
    m = (m1+m2+m3)/3;
```

```matlab
    Sw = 0; % within class variances
    for k=1:n1
        Sw = Sw + (prog1(:,k)-m1)*(prog1(:,k)-m1)';
    end
    for k=1:n2
        Sw = Sw + (prog2(:,k)-m2)*(prog2(:,k)-m2)';
    end
    for k=1:n3
        Sw = Sw + (prog3(:,k)-m3)*(prog3(:,k)-m3)';
    end

    sb1 = (m1-m)*(m1-m)';
    sb2 = (m2-m)*(m2-m)';
    sb3 = (m3-m)*(m3-m)'; % between class
    Sb = (sb1+sb2+sb3)/3;

    [V2,D] = eig(Sb,Sw); % linear discriminant analysis
    [~,ind] = max(abs(diag(D)));
    w = V2(:,ind); w = w/norm(w,2);

    vg1 = w'*prog1;
    vg2 = w'*prog2;
    vg3 = w'*prog3;

    sortg1 = sort(vg1);
    sortg2 = sort(vg2);
    sortg3 = sort(vg3);

    threshold1 = mean(sortg2);
    threshold2 = mean(sortg3);
end
```