Assignment 3 CSC 475

Hector Perez V00794415

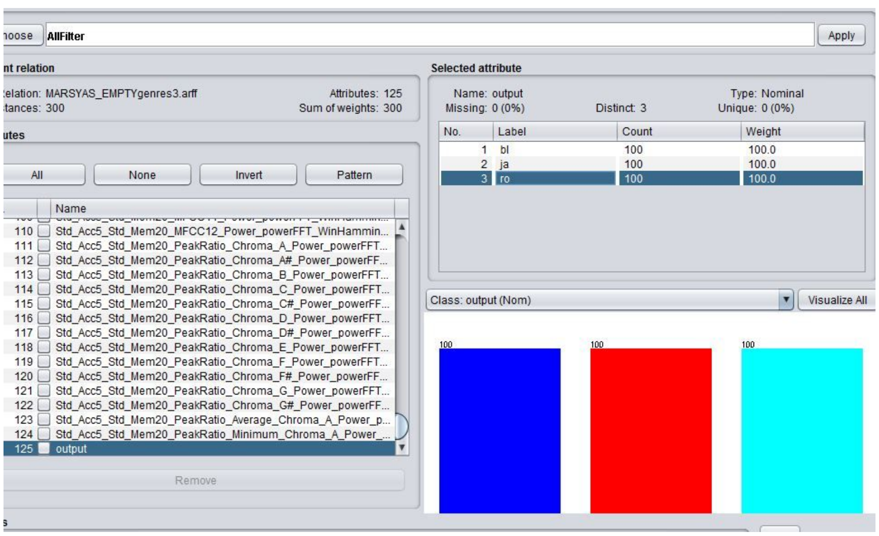
Part 1. Section A

- Please check the section at the end of part 2 (generation of random songs).

- List of commands used: (Included in each experiment as well)

`ZeroR -batch-size-10` (for the Zero R classifier).
`NaiveBayes -K` (for the Naive Bayes classifier).
`J48 -C 0.25 M 2` (for the J48 Classifier)
`J48 -U M5 -A -doNotMakeSplitPointActualValue.` (for the J48 Classifier)
SMO -C 1.0 -L 0.001 -P 1.0E-12 -N 0 -V -1 -W 1 -K "weka.classifiers.functions.supportVector.PolyKernel -E 1.0 -C 250007" -calibrator "weka.classifiers.functions.Logistic -R 1.0E-8 -M -1 -num-decimal-places 4" (for the SMO Classifier)
The commands used for SciKit Learn are included in the code portions (greyed out).

This is the result of importing the .arff file into Weka. (Bextract was successful).



The **ZeroR** classifier returned the following confusion matrix and accuracy:

```
ZeroR predicts class value: bl

=== Summary ===

Correctly Classified Instances         100               33.3333 %
Incorrectly Classified Instances       200               66.6667 %
Total Number of Instances              300

=== Confusion Matrix ===

   a   b   c   <-- classified as
 100   0   0 |   a = bl
 100   0   0 |   b = ja
 100   0   0 |   c = ro
```

Discussion: There is large error because the class predicted for all instances is the same one. The confusion matrix shows this clearly, as there is no correctly identified instances for jazz and rock (these would appear in the diagonal).

Invoking the **NaiveBayes** as is, we get the following classif. accuracy and confusion matrix.

```
=== Stratified cross-validation ===

=== Summary ===

Correctly Classified Instances         224               74.6667 %
Incorrectly Classified Instances        76               25.3333 %
Total Number of Instances              300

=== Confusion Matrix ===

  a  b  c   <-- classified as
 64 19 17 |  a = bl
 11 81  8 |  b = ja
 12  9 79 |  c = ro
```

Discussion: The accuracy is good. Blues was the least correctly classified, because only 64/100 were classified correctly. Jazz was the most correctly classified, with 81/100 correct. The NaiveBayes algorithm computes probabilities assuming conditional independence between variables. The class predicted is determined by comparing the probabilities.

Weka allows to choose NaiveBayes -D (Supervised discretization) or NaiveBayes -K (Use Kernel Estimator). From these two, Kernel estimator did better, with 76% accuracy.

Command: NaiveBayes -K

```
=== Summary ===

Correctly Classified Instances         229               76.3333 %
Incorrectly Classified Instances        71               23.6667 %
Total Number of Instances              300

=== Confusion Matrix ===

  a  b  c   <-- classified as
 69 13 18 |  a = bl
 13 79  8 |  b = ja
 10  9 81 |  c = ro
```

Discussion: The Kernel estimator did not do such a large difference, but it did increase the accuracy.

Invoking the **J48** classifier as is, which is under 'Tree' classifiers in Weka returns the following. (10-fold and 70% split were the best results, but the 10-fold was better).

Command: J48 -C 0.25 M 2
Names of parameters: C - confidence factor, M - minimum number of objects.

```
=== Summary ===

Correctly Classified Instances         231               77      %
Incorrectly Classified Instances        69               23      %
Total Number of Instances              300

=== Confusion Matrix ===

  a  b  c   <-- classified as
 77  7 16 |  a = bl
  8 79 13 |  b = ja
 19  6 75 |  c = ro
```

Discussion: The tree created is very complex, and would be really hard/near impossible to do it by hand. All the classes were classified fairly well, with about 20-25 classified incorrectly.

Other parameters were tried, but none had significant impact on accuracy.

After modifying some of them and trying out which gave better accuracy, the results were:
Command used: J48 -U M5 -A -doNotMakeSplitPointActualValue.

```
=== Summary ===

Correctly Classified Instances         223               74.3333 %
Incorrectly Classified Instances        77               25.6667 %
Total Number of Instances              300

=== Confusion Matrix ===

  a  b  c   <-- classified as
 72 12 16 |  a = bl
  8 81 11 |  b = ja
 23  7 70 |  c = ro
```

Discussion: The accuracy was lower than the defaults used by Weka. Jazz was the most correctly classified genre.

SMO has many parameters. In weka it is categorized under 'functions'.

SMO stands for sequential minimal optimization, and is related to support vector machines.

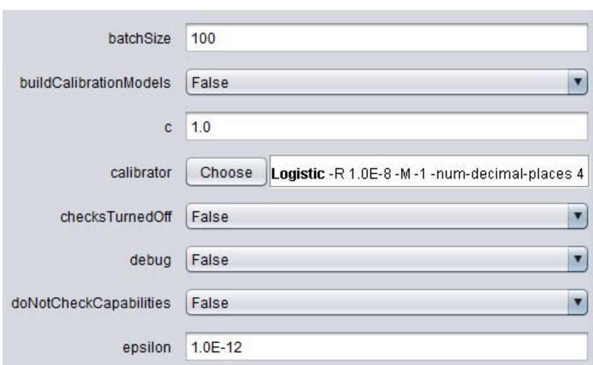
As it is, the command to invoke it is:
SMO -C 1.0 -L 0.001 -P 1.0E-12 -N 0 -V -1 -W 1 -K "weka.classifiers.functions.supportVector.PolyKernel -E 1.0 -C 250007" -calibrator "weka.classifiers.functions.Logistic -R 1.0E-8 -M -1 -num-decimal-places 4"

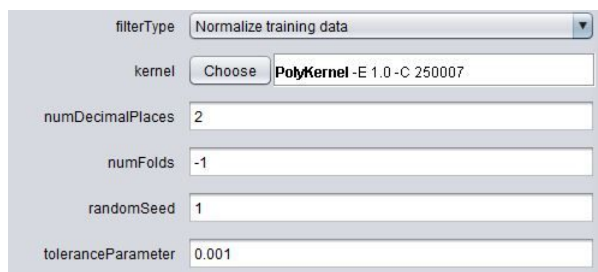
The results are:

```
=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances         268               89.3333 %
Incorrectly Classified Instances        32               10.6667 %
Total Number of Instances              300

=== Confusion Matrix ===

  a  b  c   <-- classified as
 89  1 10 |  a = bl
  3 94  3 |  b = ja
 13  2 85 |  c = ro
```

Discussion: This is the highest accuracy achieved with any of the previous methods.

The parameters shown are:





I try different kernels as this seems to be an important parameter.
Using NormalizedPolyKernel reduced accuracy to 84%.
Using RBFKernel reduced accuracy to 75%.
Using ‘Puk’ reduced accuracy to 87%.
Using percentage splits instead of folds, the results were all lower than when using folds.

Discussion: SMO has high accuracy compared to NaiveBayes, J48 tree, and ZeroR.

Part 1. Section B. Trials with **Scikit-learn** in Python.

I converted the .arff file to .libsvm which should work with Scikit learn.
I have Anaconda installed so I checked if it was already included, and it appears to be.

The categories in Weka for the classifiers previously used are:
a)ZeroR - 'Rules' b)NaiveBayes - 'Bayesian' c)J48 - 'Tree' d)SMO - 'Functions.

I couldn't find one-to-one correspondence for ZeroR, J48 and SMO , so I decided to use the following three classifiers, one related to support vector machines, one related to naive bayes, and one related to decision trees:
1. sklearn.svm.SVC *(As in video tutorial by George Tzanetakis.)*
2. sklearn.naive_bayes.GaussianNB.
3. sklearn.tree.DecisionTreeClassifier.

1. Support Vector Classification - sklearn.svm.SVC.

```
import sklearn
import matplotlib.pyplot as plt
from sklearn.datasets import load_svmlight_file
from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score
from sklearn import svm
from sklearn.metrics import confusion_matrix

#Some parts of this come from George Tzanetakis's implementation
#in the video from mirBook/course site for csc 475.

print "---------Implementation of a classifier with Support Vector Machine---------------"
    X, y = load_svmlight_file('a3.libsvm');
    print("Total number of instances: %d" %X.shape[0]);
    X_train, X_test, y_train, y_test = train_test_split(X,y,test_size=0.4,random_state = 0);
    print("Num Instances of the training set : %d" % X_train.shape[0]);
    print("Num Instances of the testing set : %d" % X_test.shape[0]);
#this is the classifier -> creates a model from the data by calling .fit()
    clf = svm.SVC(kernel = 'linear', C=1).fit(X_train, y_train);
#compute confusion matrix
    y_pred = clf.predict(X_test); #this is a list of 0 = blues, 1 = jazz, and 2 = rock
    y_true = y_test; #ground truth
    c_m = confusion_matrix(y_true, y_pred);
    labels = ["blues","jazz","rock"];
    categories = ["a","b","c"];
    print " a  b  c <-- classified as";
    for i in range(3):
        print c_m[i],
        print("| %s = %s" % (categories[i],labels[i]));

#running cross validation w 5 folds:
    scores = cross_val_score(clf, X_test, y_test , cv = 5);
    print("Accuracy: %0.2f (+/- %0.2f)" % (scores.mean(), scores.std()*2) );
```

The output of this program was:

```
---------Implementation of a classifier with Support Vector Machine---------------

Total number of instances: 300
Num Instances of the training set : 180
Num Instances of the testing set : 120

 a  b  c <-- classified as
[41  1  3] | a = blues
[ 4 27  4] | b = jazz
[ 8  1 31] | c = rock

Accuracy: 0.72 (+/- 0.16)
```

2. Gaussian Naive Bayes

```
import sklearn
import numpy as np
from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import confusion_matrix
from sklearn.datasets import load_svmlight_file
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import train_test_split

print "---------Implementation of a classifier with Gaussian Naive Bayes---------------"
X, y = load_svmlight_file('a3.libsvm');
print("Total number of instances: %d" %X.shape[0]);
X_train, X_test, y_train, y_test = train_test_split(X,y,test_size=0.4, random_state = 0);
print("Num Instances of the training set : %d" % X_train.shape[0]);
print("Num Instances of the testing set : %d" % X_test.shape[0]);
X_train = X_train.toarray();                #X’s must be np.array -requested by compiler
X_test = X_test.toarray();                  #because these are 'dense' scikit matrix
clf = GaussianNB().fit(X_train, y_train);   #however, the y's are np.arrays
y_pred = clf.predict(X_test);               #so there's no need to fix that.
y_true = y_test;
c_m = confusion_matrix(y_true, y_pred);
labels = ["blues","jazz","rock"];
categories = ["a","b","c"];
print " a  b  c <-- classified as";
for i in range(3):
       print c_m[i],
       print("| %s = %s" % (categories[i],labels[i]));
scores = cross_val_score(clf, X_test, y_test , cv = 5);
print("Accuracy: %0.2f (+/- %0.2f)" % (scores.mean(), scores.std()*2) );
```

The output of this program was:

```
---------Implementation of a classifier with Gaussian Naive Bayes---------------

Total number of instances: 300
Num Instances of the training set : 180
Num Instances of the testing set : 120

 a  b  c <-- classified as
[29  4 12] | a = blues
[ 0 24 11] | b = jazz
[ 2  1 37] | c = rock

Accuracy: 0.73 (+/- 0.22)
```

3. Decision Tree Classifier

```
import sklearn
from sklearn import tree
from sklearn.metrics import confusion_matrix
from sklearn.datasets import load_svmlight_file
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import train_test_split

X, y = load_svmlight_file('a3.libsvm');
print "---------Implementation of a classifier with DecisionTreeClassifier---------------"
print("Total number of instances: %d" %X.shape[0]);
X_train, X_test, y_train, y_test = train_test_split(X,y,test_size=0.4, random_state = 0);
print("Num Instances of the training set : %d" % X_train.shape[0]);
print("Num Instances of the testing set : %d" % X_test.shape[0]);
clf = tree.DecisionTreeClassifier();
clf = clf.fit(X_train, y_train);
y_pred = clf.predict(X_test); #this is a list of 0 = blues, 1 = jazz, and 2 = rock
y_true = y_test; #ground truth
c_m = confusion_matrix(y_true, y_pred);
labels = ["blues","jazz","rock"];
categories = ["a","b","c"];
print " a   b   c  <-- classified as";
for i in range(3):
       print c_m[i],
       print("| %s = %s" % (categories[i],labels[i]));
scores = cross_val_score(clf, X_test, y_test , cv = 5);
print("Accuracy: %0.2f (+/- %0.2f)" % (scores.mean(), scores.std()*2) );
```

The output of this program was:

```
---------Implementation of a classifier with DecisionTreeClassifier---------------

Total number of instances: 300
Num Instances of the training set : 180
Num Instances of the testing set : 120

 a   b   c  <-- classified as
[30  5 10] | a = blues
[ 5 25  5] | b = jazz
[ 8  0 32] | c = rock

Accuracy: 0.62 (+/- 0.14)
```

The results were that the Gaussian Naive Bayes classifier achieved the highest accuracy, closely followed by the Support Vector Classifier. The decision tree classifier had some parameters that could be changed, but I wanted to see how it fended off with the default settings. It was the lowest out of the three classifiers.

Each genre by itself was well classified by the following classifiers:

Classifier	Blues	Jazz	Rock
Good at classifying genre	SVC	SVC	Naive Bayes
Bad at classifying genre	Naive Bayes	Naive Bayes	SVC

I did notice something that happened with the train_test_split, which is that although the number of instances is indeed the correct split size (e.g. 0.4 of 300 is 120) the number of instances per class were not equal. In Weka they were always the same amount per each class.

Part 2

A) Write code to calc. Probabilities for each dictionary word given the genre.

Probabilities found:

Rap	Rock Pop	Country
Probabilities For Rap de : 0.08700 niggaz : 0.18500 ya : 0.43900 und : 0.06200 yall : 0.28200 ich : 0.05700 fuck : 0.41200 shit : 0.50800 yo : 0.41100 bitch : 0.31200 end : 0.17900 wait : 0.11600 again : 0.17100 light : 0.19600 eye : 0.23200 noth : 0.12000 lie : 0.11100 fall : 0.14100 our : 0.21400 away : 0.16200 gone : 0.17300 good : 0.26900 night : 0.22400 blue : 0.09500 home : 0.18900 long : 0.18300 littl : 0.24100 well : 0.21300 heart : 0.16400 old : 0.14100	Probabilities For Rock Pop de : 0.03700 niggaz : 0.00600 ya : 0.04500 und : 0.03100 yall : 0.00600 ich : 0.02600 fuck : 0.08700 shit : 0.04000 yo : 0.02200 bitch : 0.01800 end : 0.19900 wait : 0.18900 again : 0.22000 light : 0.19900 eye : 0.30800 noth : 0.19100 lie : 0.18500 fall : 0.22300 our : 0.23700 away : 0.32000 gone : 0.15300 good : 0.15700 night : 0.26400 blue : 0.06300 home : 0.16000 long : 0.17800 littl : 0.14700 well : 0.19600 heart : 0.26000 old : 0.11000	Probabilities For Country de : 0.00600 niggaz : 0.00300 ya : 0.05100 und : 0.00000 yall : 0.01900 ich : 0.00000 fuck : 0.00800 shit : 0.01100 yo : 0.01200 bitch : 0.00500 end : 0.14300 wait : 0.13900 again : 0.20900 light : 0.18900 eye : 0.26100 noth : 0.12400 lie : 0.09500 fall : 0.17000 our : 0.20600 away : 0.26900 gone : 0.20300 good : 0.27300 night : 0.37300 blue : 0.16000 home : 0.25600 long : 0.31400 littl : 0.31100 well : 0.32000 heart : 0.37100 old : 0.29500

Code: (I eliminated some print statements).

```
import numpy as np

data = np.load('csc475_asn3_data/data.npz');
dataArray = data['arr_0'];

labels = np.load('csc475_asn3_data/labels.npz');
labelsArray = labels['arr_0'];
genres = dict([(12,'Rap'), (1,'Rock Pop'),(3,'Country')]);
words = np.load('csc475_asn3_data/words.npz');
dictionary = np.load('csc475_asn3_data/dictionary.pck');
wordsArray = [];
for i in words['arr_0']:
       wordsArray.append(dictionary[i]);
countForWordsRap = np.zeros(len(wordsArray)); #stores counts.
countForWordsRockPop = np.zeros(len(wordsArray));
countForWordsCountry = np.zeros(len(wordsArray));
```

```
probabilityForGenre = 1000/3000.0;
probabilitiesForWords = np.zeros(len(wordsArray));
probabilitiesForWordsRap = np.zeros(len(wordsArray));
probabilitiesForWordsRockPop = np.zeros(len(wordsArray));
probabilitiesForWordsCountry = np.zeros(len(wordsArray));

tracksArray = np.load('csc475_asn3_data/tracks.pck');

previousGenre = '';

for i in range(len(dataArray)):
	currentGenre = labelsArray[i];

	if(currentGenre != previousGenre):
		print("Currently analysing: %s" % genres[currentGenre]);
		print;

	for j in range (len(wordsArray)):
		if dataArray[i][j] > 0:
			if currentGenre == 12:
				countForWordsRap[j] += 1;
			elif currentGenre == 1:
				countForWordsRockPop[j] += 1;
			else:
				countForWordsCountry[j] +=1;

	previousGenre = currentGenre;

#here there were some print statements

#compute the probabilites
#a. get overall probability P(word) = is N_inst_with_Word / 3000;

for i in range (len(wordsArray)):
	#probs for individual word in the whole dataset
	probabilitiesForWords[i] =
(countForWordsRap[i]+countForWordsRockPop[i]+countForWordsCountry[i])/3000.0;

	#conditional probs. --- Using general multiplication rule.
	#  Since P(A and B) = P(A) * P(B|A)
    #  P(B|A) = P(A and B) / P(A)
    #  P(word|genre) = P(word and genre) / P(genre);

	#  P(word and genre) = #instances with the word that are that genre /  total number
of instances.
	#  P(genre) = 1/3.

	probabilitiesForWordsRap[i] = (countForWordsRap[i]/3000.0)/probabilityForGenre;
	probabilitiesForWordsRockPop[i] =
(countForWordsRockPop[i]/3000.0)/probabilityForGenre;
	probabilitiesForWordsCountry[i] =
(countForWordsCountry[i]/3000.0)/probabilityForGenre;
```

B) Explain how these probability estimates can be combined to form a Naive Bayes classifier. Calculate the classification accuracy and confusion matrix that you would obtain using the whole data set for both training and testing partitions. (1pt, 0.5pt)

Using the probabilities, we can find P(Genre | X = feature vector) for all three genres. The Bayes' rule and assumption of conditional independence, allows us to compute this by multiplication of conditional probabilities. The genre with highest probability will be the class that a new instance is labeled as.

$$P(Genre|X_{features}) = P(Genre) * \prod_{i=1}^{n} P(X_i|Genre)$$

Results: (Confusion matrix and accuracy).

```
     a        b        c
   751      154       95 | a = Rap
    64      629      307 | b = Rock Pop
    28      263      709 | c = Country

Accuracy: 69.63 %
```

Code: findProbabilities.py and genreclf_b.py (with some prints eliminated)

```
import numpy as np

def trainModel(dataArray, labelsArray, genres, wordsArray,
probabilitiesForWords,probabilitiesForWordsRap,probabilitiesForWordsRockPop,probabilitiesFor
WordsCountry):
       probabilityForGenre = 1000/3000.0;
       countForWordsRap = np.zeros(len(wordsArray));
       countForWordsRockPop = np.zeros(len(wordsArray));
       countForWordsCountry = np.zeros(len(wordsArray));
       previousGenre = '';
       for i in range(len(dataArray)):
              currentGenre = labelsArray[i];
              if(currentGenre != previousGenre):
                     print("Currently analysing: %s" % genres[currentGenre]);
                     print;
              for j in range (len(wordsArray)):
                     if dataArray[i][j] > 0:
                            if currentGenre == 12:
                                   countForWordsRap[j] += 1;
                            elif currentGenre == 1:
                                   countForWordsRockPop[j] += 1;
                            else:
                                   countForWordsCountry[j] +=1;
              previousGenre = currentGenre;
       for i in range (len(wordsArray)):
              probabilitiesForWords[i] =
(countForWordsRap[i]+countForWordsRockPop[i]+countForWordsCountry[i])/3000.0;
              probabilitiesForWordsRap[i] =
(countForWordsRap[i]/3000.0)/probabilityForGenre;
              probabilitiesForWordsRockPop[i] =
(countForWordsRockPop[i]/3000.0)/probabilityForGenre;
              probabilitiesForWordsCountry[i] =
(countForWordsCountry[i]/3000.0)/probabilityForGenre;
```

```
def testModel(dataArray, labelsArray, genres, wordsArray,
probabilitiesForWords,probabilitiesForWordsRap,probabilitiesForWordsRockPop,probabilitiesFor
WordsCountry):
	probabilityForGenre = 1000/3000.0;
	classification = np.zeros(len(dataArray));
	for i in range (len(dataArray)):
		probabilityRap = probabilityForGenre;
		probabilityRockPop = probabilityForGenre;
		probabilityCountry = probabilityForGenre;
		for j in range (len(wordsArray)):
			if dataArray[i][j]<=0:
				probabilityRap *= (1-probabilitiesForWordsRap[j]);
				probabilityRockPop *= (1-probabilitiesForWordsRockPop[j]);
				probabilityCountry *= (1-probabilitiesForWordsCountry[j]);
			if dataArray[i][j]>0:
				probabilityRap *= probabilitiesForWordsRap[j];
				probabilityRockPop *= probabilitiesForWordsRockPop[j];
				probabilityCountry *= probabilitiesForWordsCountry[j]
		MAX_A_POST = np.argmax([probabilityRap, probabilityRockPop,
probabilityCountry]);
		if(MAX_A_POST == 0):classification[i] = 12;
		elif(MAX_A_POST == 1):classification[i] = 1;
		elif(MAX_A_POST == 2):classification[i] = 3;
	return classification;

def accuracyAndConfusionMatrix(classification,labelsArray):
	correctCounter = 0;
	matrix = [[0,0,0],[0,0,0],[0,0,0]];
	for i in range (len(labelsArray)):
		if(classification[i] == labelsArray[i]):
			correctCounter += 1;
		    if labelsArray[i] == 12 and classification[i] == 12: matrix[0][0] += 1;
		    elif labelsArray[i] == 1 and classification[i] == 1: matrix[1][1] += 1;
		    elif labelsArray[i] == 3 and classification[i] == 3: matrix[2][2] += 1;
		else:
			#rap classified as rock pop
		    if labelsArray[i] == 12 and classification[i] == 1: matrix[0][1] += 1;
			#rap classified as country
		    elif labelsArray[i] == 12 and classification[i] == 3: matrix[0][2] += 1;
			#rock pop classified as rap
		    elif labelsArray[i] == 1 and classification[i] == 12: matrix[1][0] += 1;
			#rock pop classified as country
		    elif labelsArray[i] == 1 and classification[i] == 3: matrix[1][2] += 1;
			#country classified as rap
		    elif labelsArray[i] == 3 and classification[i] == 12: matrix[2][0] += 1;
			#country classf as rock pop
		    elif labelsArray[i] == 3 and classification[i] == 1: matrix[2][1] += 1;
	totalInst = 3000.0;
	accuracy = correctCounter/totalInst;
	accuracyPercentage = accuracy*100.0;
	labels = ["Rap","Rock Pop","Country"];
	categories = ["a","b","c"];
	print( "%8s %8s %8s" % (categories[0], categories[1], categories[2]));
	for i in range(3):
		print("%8d %8d %8d" %(matrix[i][0], matrix[i][1], matrix[i][2])),
		print("| %s = %s" % (categories[i],labels[i]));
	print;
	print("Accuracy: %0.2f %% " % accuracyPercentage );
```

```
import numpy as np
import findProbabilities

class genreclf_b():
	def main():
		data = np.load('csc475_asn3_data/data.npz');
		dataArray = data['arr_0'];
		labels = np.load('csc475_asn3_data/labels.npz');
		labelsArray = labels['arr_0'];
		genres = dict([(12,'Rap'), (1,'Rock Pop'),(3,'Country')]);
		words = np.load('csc475_asn3_data/words.npz');
		dictionary = np.load('csc475_asn3_data/dictionary.pck');
		wordsArray = [];
		for i in words['arr_0']:
			wordsArray.append(dictionary[i]);
		probabilitiesForWords = np.zeros(len(wordsArray));
		probabilitiesForWordsRap = np.zeros(len(wordsArray));
		probabilitiesForWordsRockPop = np.zeros(len(wordsArray));
		probabilitiesForWordsCountry = np.zeros(len(wordsArray));
		tracksArray = np.load('csc475_asn3_data/tracks.pck');
		findProbabilities.trainModel(dataArray, labelsArray, genres, wordsArray,
probabilitiesForWords,probabilitiesForWordsRap,probabilitiesForWordsRockPop,probabilitiesFor
WordsCountry);
		classification = findProbabilities.testModel(dataArray, labelsArray, genres,
wordsArray,probabilitiesForWords,probabilitiesForWordsRap,probabilitiesForWordsRockPop,proba
bilitiesForWordsCountry);
		findProbabilities.accuracyAndConfusionMatrix(classification, labelsArray);
		return 0;
	if __name__ == "__main__": main()
```

C) Read the Wikipedia page about cross-validation in statistics Calculate the classification accuracy and confusion matrix using the k−fold cross-validation, where k = 10. Note that you would use both the training and testing data and generate your own splits. (2pt, 1pt)

Results: I iterated several times and achieved a similar accuracy to not doing cross validation. Two iterations show this accuracy and confusion matrices.

```
     a        b        c
   784      134       82 | a = Rap
    91      579      330 | b = Rock Pop
    30      281      689 | c = Country

Accuracy: 68.40 %
```

```
     a        b        c
   753      139      108 | a = Rap
    81      599      320 | b = Rock Pop
    19      270      711 | c = Country

Accuracy: 68.77 %
```

Code:

```
import numpy as np
import findProbabilities2

class genreclf_b():

       def main():
              k = 10;
              data = np.load('csc475_asn3_data/data.npz');
              dataArray = data['arr_0'];
              indexes = np.arange(3000);
              np.random.shuffle(indexes);
              labels = np.load('csc475_asn3_data/labels.npz');
              labelsArray = labels['arr_0'];
              newData = [[]*30]*3000;
              newLabels = np.zeros(3000);
              for i in range (3000):
                     newData[i] = dataArray[indexes[i]];
                     newLabels[i] = labelsArray[indexes[i]];
              words = np.load('csc475_asn3_data/words.npz');
              dictionary = np.load('csc475_asn3_data/dictionary.pck');
              wordsArray = [];
              for i in words['arr_0']:
                     wordsArray.append(dictionary[i]);
              probabilitiesForWords = np.zeros(len(wordsArray));
              probabilitiesForWordsRap = np.zeros(len(wordsArray));
              probabilitiesForWordsRockPop = np.zeros(len(wordsArray));
              probabilitiesForWordsCountry = np.zeros(len(wordsArray));
              main_matrix = [[0,0,0],[0,0,0],[0,0,0]];
              main_accuracy = 0;
              accuracySum = 0;
              for i in range (k):
                     testingData = newData[i*300:(i+1)*300];
                     labelsData = newLabels[i*300:(i+1)*300];
                     findProbabilities2.trainModel(k,i, newData, newLabels, wordsArray,
probabilitiesForWords,probabilitiesForWordsRap,probabilitiesForWordsRockPop,probabilitiesFor
WordsCountry);
                     classification = findProbabilities2.testModel(testingData, wordsArray,
probabilitiesForWords,probabilitiesForWordsRap,probabilitiesForWordsRockPop,probabilitiesFor
WordsCountry);
                     accuracy =
findProbabilities2.calculateAccuracy(classification,labelsData);
                     accuracySum = accuracySum+accuracy;
                     iterationConfusionMatrix =
findProbabilities2.calculateConfusionMatrix(classification,labelsData);
                     main_matrix = np.add(main_matrix, iterationConfusionMatrix );
              main_accuracy = accuracySum/k;
              main_accuracy = main_accuracy*100.0;
              labels = ["Rap","Rock Pop","Country"];
              categories = ["a","b","c"];
              print( "%8s %8s %8s" % (categories[0], categories[1], categories[2]));
              for i in range(3):
                     print("%8d %8d %8d" %(main_matrix[i][0], main_matrix[i][1],
main_matrix[i][2])),
                     print("| %s = %s" % (categories[i],labels[i]));
              print;
              print("Accuracy: %0.2f %% " % main_accuracy );
              return 0;
       if __name__ == "__main__": main()
```

```
import numpy as np

def trainModel(k,index, newData, newLabels , wordsArray, 
probabilitiesForWords,probabilitiesForWordsRap,probabilitiesForWordsRockPop,probabilitiesFor
WordsCountry):
        probabilityForGenre = 1000.0/3000.0;
        countForWordsRap = np.zeros(len(wordsArray));
        countForWordsRockPop = np.zeros(len(wordsArray));
        countForWordsCountry = np.zeros(len(wordsArray));
        number = 0;
        for i in range(k):
                if i != index:
                        currentSubset = newData[i*300:(i+1)*300];
                        countWords(number, currentSubset,newData,newLabels, wordsArray, 
countForWordsRap,countForWordsRockPop,countForWordsCountry);
        for i in range (len(wordsArray)):
                probabilitiesForWords[i] = 
(countForWordsRap[i]+countForWordsRockPop[i]+countForWordsCountry[i])/2700.0;
                probabilitiesForWordsRap[i] = 
(countForWordsRap[i]/2700.0)/probabilityForGenre;
                probabilitiesForWordsRockPop[i] = 
(countForWordsRockPop[i]/2700.0)/probabilityForGenre;
                probabilitiesForWordsCountry[i] = 
(countForWordsCountry[i]/2700.0)/probabilityForGenre;

def countWords(number, currentSubset, newData, newLabels, wordsArray, countForWordsRap, 
countForWordsRockPop, countForWordsCountry):
        for j in range(len(currentSubset)):
                genre = newLabels[j] ;
                for m in range(len(wordsArray)):
                        if newData[j][m] > 0:
                                if genre == 12:countForWordsRap[m] += 1;
                                elif genre == 1:countForWordsRockPop[m] += 1;
                                else: countForWordsCountry[m] +=1;

def testModel(testingData, wordsArray, 
probabilitiesForWords,probabilitiesForWordsRap,probabilitiesForWordsRockPop,probabilitiesFor
WordsCountry):
        probabilityForGenre = 1000/3000.0;
        classification = np.zeros(len(testingData));
        for i in range (len(testingData)):
                probabilityRap = probabilityForGenre;
                probabilityRockPop = probabilityForGenre;
                probabilityCountry = probabilityForGenre;
                for j in range (len(wordsArray)):
                        if testingData[i][j]<=0:
                                probabilityRap *= (1-probabilitiesForWordsRap[j]);
                                probabilityRockPop *= (1-probabilitiesForWordsRockPop[j]);
                                probabilityCountry *= (1-probabilitiesForWordsCountry[j]);
                        if testingData[i][j]>0:
                                probabilityRap *= probabilitiesForWordsRap[j];
                                probabilityRockPop *= probabilitiesForWordsRockPop[j];
                                probabilityCountry *= probabilitiesForWordsCountry[j]
        MAX_A_POST = np.argmax([probabilityRap, probabilityRockPop, probabilityCountry]);
                if(MAX_A_POST == 0):classification[i] = 12;
                elif(MAX_A_POST == 1):classification[i] = 1;
                elif(MAX_A_POST == 2):classification[i] = 3;
        return classification;
```

```
def calculateAccuracy(classification,labelsArray):
	correctCounter = 0;
	for i in range (len(labelsArray)):
		if(classification[i] == labelsArray[i]):
			correctCounter += 1;
	totalInst = 300.0;
	accuracy = correctCounter/totalInst;
	return accuracy;

def calculateConfusionMatrix(classification,labelsArray):
	matrix = [[0,0,0],[0,0,0],[0,0,0]];
	for i in range (len(labelsArray)):
		if(classification[i] == labelsArray[i]):
		if labelsArray[i] == 12 and classification[i] == 12: matrix[0][0] += 1;
		elif labelsArray[i] == 1 and classification[i] == 1: matrix[1][1] += 1;
		elif labelsArray[i] == 3 and classification[i] == 3: matrix[2][2] += 1;
		else:
			#rap classified as rock pop
			if labelsArray[i] == 12 and classification[i] == 1: matrix[0][1] += 1;
			#rap classified as country
		elif labelsArray[i] == 12 and classification[i] == 3: matrix[0][2] += 1;
			#rock pop classified as rap
		elif labelsArray[i] == 1 and classification[i] == 12: matrix[1][0] += 1;
			#rock pop classified as country
		elif labelsArray[i] == 1 and classification[i] == 3: matrix[1][2] += 1;
			#country classified as rap
		elif labelsArray[i] == 3 and classification[i] == 12: matrix[2][0] += 1;
			#country classf as rock pop
		elif labelsArray[i] == 3 and classification[i] == 1: matrix[2][1] += 1;
	return matrix;
```

Part 2.4 Generation of random songs from the model created.(And output)
Code: generateSongs.py

```
Must import findProbabilities, import auxForGenerateSongs, import numpy as np

class generateSongs():
	def main():
		data = np.load('csc475_asn3_data/data.npz');
		dataArray = data['arr_0'];
		words = np.load('csc475_asn3_data/words.npz');
		dictionary = np.load('csc475_asn3_data/dictionary.pck');
		wordsArray = [];
		for i in words['arr_0']: wordsArray.append(dictionary[i]);
		probabilitiesForWords = np.zeros(len(wordsArray));
		probabilitiesForWordsRap = np.zeros(len(wordsArray));
		probabilitiesForWordsRockPop = np.zeros(len(wordsArray));
		probabilitiesForWordsCountry = np.zeros(len(wordsArray));
		findProbabilities.trainModel(dataArray, labelsArray, genres, wordsArray,
probabilitiesForWords,probabilitiesForWordsRap,probabilitiesForWordsRockPop,probabilitiesFor
WordsCountry);
		print 'Generating 5 Rap Songs'
		auxForGenerateSongs.generate5Songs(probabilitiesForWordsRap, wordsArray);
		print 'Generating 5 Rock Pop Songs'
		auxForGenerateSongs.generate5Songs(probabilitiesForWordsRockPop, wordsArray);
		print 'Generating 5 Country Songs'
		auxForGenerateSongs.generate5Songs(probabilitiesForWordsCountry, wordsArray);
		return 0;
	if __name__ == "__main__": main()
```

Code: auxForGenerateSongs.py

```
import numpy as np
def generate5Songs(probabilitiesArray, wordsArray):
	numSongs = 5;
	limit = 30;
	wordsInSong = [];
	for n in range(numSongs):
		for m in range(limit):
			randomProbability = np.random.random();
			randomIndex = np.random.randint(0,limit);
			if(randomProbability > probabilitiesArray[randomIndex]):
				wordsInSong = np.append(wordsInSong,wordsArray[randomIndex]);
		print wordsInSong;
		wordsInSong = [];
```

Output

```
Generating 5 Rap Songs
----------------------------------------------------
['away' 'night' 'niggaz' 'de' 'long' 'away' 'again' 'away' 'lie' 'niggaz' 'heart' 'old' 'yo'
'yall' 'niggaz' 'end' 'heart' 'our' 'de' 'eye' 'und' 'again' 'de' 'bitch' 'und']

['blue' 'lie' 'noth' 'yo' 'ya' 'wait' 'light' 'end' 'wait' 'away' 'long' 'long' 'blue' 'our'
'shit' 'end' 'yo' 'light' 'night' 'heart' 'bitch' 'well' 'our' 'old' 'ya']

['de' 'end' 'gone' 'good' 'eye' 'lie' 'gone' 'niggaz' 'again' 'gone' 'gone' 'fall' 'lie'
'old' 'away' 'end' 'light' 'good' 'noth' 'wait']

['lie' 'blue' 'und' 'old' 'littl' 'shit' 'light' 'blue' 'well' 'wait' 'away' 'littl' 'long'
'und' 'away' 'yall' 'noth' 'eye' 'away' 'niggaz' 'gone' 'again' 'blue' 'blue' 'our' 'good']

['fall' 'long' 'heart' 'old' 'heart' 'yo' 'yall' 'niggaz' 'ya' 'de' 'wait' 'yall' 'old'
'blue' 'wait' 'noth' 'good' 'yo' 'our' 'blue' 'old' 'niggaz' 'well' 'littl' 'fall']
----------------------------------------------------
Generating 5 Rock Pop Songs
----------------------------------------------------
['fuck' 'old' 'ich' 'eye' 'ich' 'und' 'fuck' 'bitch' 'away' 'fuck' 'bitch' 'niggaz' 'littl'
'night' 'home' 'und' 'our' 'again' 'ya' 'yo' 'niggaz' 'und' 'old' 'gone' 'ya' 'our' 'home']

['fall' 'heart' 'littl' 'shit' 'fall' 'lie' 'lie' 'away' 'shit' 'away' 'fuck' 'yall' 'noth'
'de' 'away' 'night' 'shit' 'und' 'light' 'fall' 'und' 'lie' 'niggaz' 'littl' 'lie' 'well']

['noth' 'old' 'shit' 'littl' 'home' 'light' 'our' 'und' 'away' 'well' 'well' 'lie' 'niggaz'
'niggaz' 'night' 'fuck' 'eye' 'home' 'good' 'yo' 'fall' 'niggaz' 'de' 'fuck' 'shit']

['gone' 'yall' 'light' 'fall' 'home' 'yo' 'wait' 'ya' 'blue' 'heart' 'wait' 'noth' 'fuck'
'de' 'well' 'littl' 'shit' 'de' 'und' 'yo' 'shit' 'gone' 'niggaz' 'ya']

['night' 'yall' 'old' 'ya' 'shit' 'bitch' 'long' 'light' 'well' 'yall' 'fuck' 'littl' 'end'
'fuck' 'again' 'wait' 'gone' 'de' 'long' 'bitch' 'good' 'und' 'lie' 'blue']
----------------------------------------------------
Generating 5 Country Songs
----------------------------------------------------
['noth' 'wait' 'niggaz' 'fuck' 'home' 'ich' 'blue' 'shit' 'littl' 'well' 'shit' 'well'
'night' 'noth' 'home' 'light' 'wait' 'littl' 'wait' 'und' 'gone' 'bitch' 'yall']

['ich' 'night' 'bitch' 'home' 'de' 'heart' 'shit' 'littl' 'lie' 'light' 'fuck' 'shit'
```

```
'littl' 'noth' 'gone' 'shit' 'yo' 'fuck' 'yall' 'eye' 'fall' 'fuck' 'our' 'littl' 'long']

['heart' 'our' 'de' 'yall' 'yo' 'noth' 'littl' 'noth' 'yall' 'away' 'littl' 'home' 'und'
'light' 'shit' 'away' 'ya' 'end' 'long' 'long' 'niggaz' 'yo' 'ich' 'yo' 'away' 'long''blue']

['end' 'old' 'yo' 'ich' 'fuck' 'niggaz' 'fuck' 'littl' 'fuck' 'yall' 'blue' 'yall' 'fall'
'old' 'old' 'end' 'gone' 'lie' 'niggaz' 'heart' 'wait' 'night' 'littl' 'und']

['home' 'und' 'blue' 'ya' 'end' 'night' 'heart' 'blue' 'yo' 'home' 'und' 'away' 'well'
'gone' 'de' 'de' 'yall' 'fall' 'niggaz' 'noth' 'yo' 'de']
-----------------------------------------------------
```