



University of Glasgow | Department of  
Computing Science

ARTIFICIAL INTELLIGENCE 4

ASSESSED EXERCISE

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# Sound File Signal Processing

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# 1 Design

## 1.1 Performance

The system as a whole works reasonably well, it shows 94% accuracy overall (it makes a total of 6 incorrect guesses) and executes in 6.657 seconds real time (0.168 seconds system time). More information regarding accuracy can be found in section 3.2 as well as other further information related to the performance of the system (See Section 3)

## 1.2 Environment

The environment for the system as it stands now is purely digital, that is to say, files that are read from or written to. A list of manipulated files is as follows:

- i The silence\_x.dat files (where x is a number from 01 - 50).
- ii The speech\_x.dat file (where x is a number from 01 - 50).
- iii The charts that are created.
- iv The output print statements.

The .dat files are of a static nature in this exercise (although in a real life system with actual audio sensing these would be dynamic), they are also input based.

The charts and print statements are of a dynamic nature and are output based (although, for this exercise with a static input the output is also static unless the code base is altered).

It should be noted that if raw data capture were involved in the system, that the environment could be extended to the physical space from where the sound originated.

## 1.3 Actuators

The system actuates upon whatever the standard output is for the console and prints to it. This could be in the form of a .txt file, a physical sheet of paper or even the console window itself.

## 1.4 Sensors

Techninically, the sensor for the system would be the functions as part of the standard python library that are used to read in the values of the files (as we are given the values from the files directly). In a more expanded system, where the audio is captured and sampled within the program, a microphone could also be considered as a sensor.

## 2 Theory

### 2.1 Calculating the Energy, Magnitude and ZCR

#### 2.1.1 Per Window

In the context of this specific exercise, the window size corresponds to 240 samples or 30ms (which is 10% of the total number of samples).

##### Energy

The energy was calculated using the following equation where  $w$  refers to the current window (of size 240 in the system). In plain English, each of the values within the window was squared and then summed.

$$E[n] = \sum_{k=-\infty}^{\infty} s_k^2 \cdot w[n - k]$$

##### Magnitude

The magnitude was calculated using the following equation where  $w$  refers to the current window (of size 240 in the system). In plain English, for each value in the window, the absolute was taken and then the values were summed.

$$M[n] = \sum_{k=-\infty}^{\infty} |s_k| \cdot w[n - k]$$

##### Zero Crossing Rate (ZCR)

The Zero Crossing Rate (or ZCR) was calculated using the following formula where  $w$  refers to the rectangular window.

$$Z[n] = \frac{1}{2N} \sum_{k=-\infty}^{\infty} |\text{sign}(s_k) - \text{sign}(s_{k-1})| \cdot w[n - m]$$

The function  $\text{sign}$  is as described below.

$$\text{sign}(x) = \begin{cases} 1 & \text{if } x \geq 0; \\ 0 & \text{if } x < 0. \end{cases}$$

In plain English, the ZCR is calculated by taking the sign of the current value  $s_k$  in the set  $s$  and subtracting from it the sign of the value preceding it in the set ( $s_{k-1}$ ). This value is then absolved. Finally all of these values are then summed and divided by two times the window size (480 in this system).

### 2.1.2 Per File

The values E, M and Z for each file are calculated by taking the mean value of all of the values for Energy, Magnitude and Zero Crossing Rate respectively. The mean is calculated in the standard fashion as detailed in the below equation.

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

## 2.2 K-Fold Validation

For this system, k was equal to 10 for the k-fold validation. Below is a detailed description of how I performed each step in the process.

### 2.2.1 Permuting the Data

The data (after having calculated the average Energy, Magnitude and Zero Crossing Rate for each file) was stored in 3 arrays (one each for Energy, Magnitude and ZCR) of size 100. The ordering of the array was of the pattern silence\_01, speech\_01, silence\_02, speech\_02 ... silence\_50, speech\_50. This meant that removing any subset of size 10 (which would represent the test set) from the array would always result both sets having an equal number of silence and speech files. To therefore gather the test and training sets, I simply removed a subset of  $s_i$  to  $s_{i+10}$  and used it as the test set and then used the other set as the training set. For example my first iteration's test set was from  $s_0$  to  $s_9$  and the training set was  $s_{10}$  to  $s_{99}$ . My second iteration used values  $s_{10}$  to  $s_{19}$  as the training set and  $s_0$  to  $s_9$  AND  $s_{20}$  to  $s_{99}$  as the training set.

## 2.3 Calculating the Mean and Variance

This stage involves calculating 12 values as follows:

- i The mean energy value for all silence files in the training set.
- ii The mean magnitude value for all silence files in the training set.
- iii The mean ZCR value for all silence files in the training set.
- iv The mean energy value for all speech files in the training set.
- v The mean magnitude value for all speech files in the training set.
- vi The mean ZCR value for all silence speech in the training set.
- vii The variance of energy against the mean for all silence files in the training set.
- viii The variance of magnitude against the mean for all silence files in the training set.
- ix The variance of ZCR against the mean for all silence files in the training set.
- x The variance of energy against the mean for all speech files in the training set.
- xi The variance of magnitude against the mean for all speech files in the training set.
- xii The variance of ZCR against the mean for all silence speech in the training set.

These values give us our Gaussian variables  $\mathcal{N}(m, s^2)$  where the mean is  $m$  and variance is  $s^2$ , which allow us to calculate probabilities (See Section 2.4)

### 2.3.1 The Mean

The mean was calculated in the standard fashion of summing all of the values in the set and then dividing by the total number of values in the set. This is reflected in the equation below.

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

### 2.3.2 The Variance

The following equation was used in the calculation of the variance, where  $n$  is the number of values (in the program itself  $n$  was always 45 as the number of values in the training set was 90 which accounted for 45 speech files and 45 silence files).  $E_i$  refers to the current value in the training set and  $m$  is the mean.

$$s^2 = \frac{1}{n} \sum_{i=1}^n (E_i - m)^2$$

## 2.4 Calculating Probabilities

### 2.4.1 Individually for Energy, Magnitude and ZCR

The following equation was used to discern the probability of a file being either speech or silence. The equation was applied for Energy, Magnitude and ZCR using both Gaussian variables for speech and silence.

$$p(x) = \mathcal{N}(x|m, s^2) = \frac{1}{\sqrt{2\pi s^2}} \exp\left(-\frac{(x - m)^2}{2s^2}\right)$$

### 2.4.2 Per File

Calculating an overall probability is reasonably simple, you simply multiply all of the probabilities for silence (Energy, Magnitude and ZCR based on the silence Gaussians) and also for speech (Energy, Magnitude and ZCR based on the speech Gaussians).

### 2.4.3 Making a Guess

The framework for guessing will take the largest overall probability (comparison between probability of being speech and probability of being silence) as detailed above. In the very unlikely event that the probabilities are the same, the system will guess unknown.

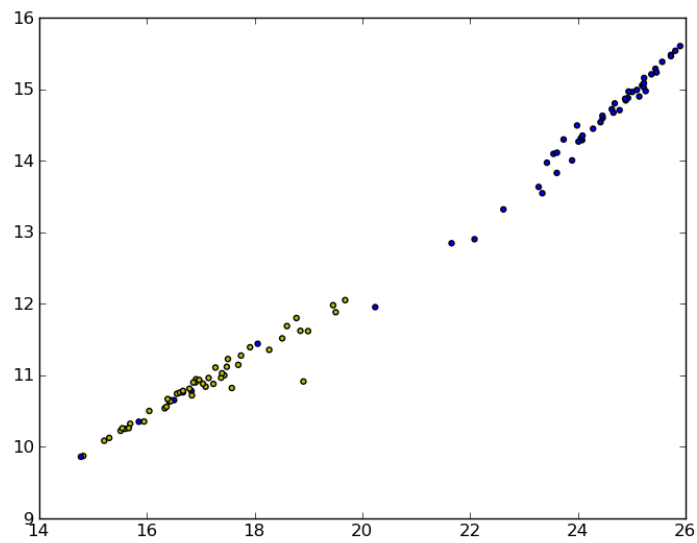


## 3 Experiments

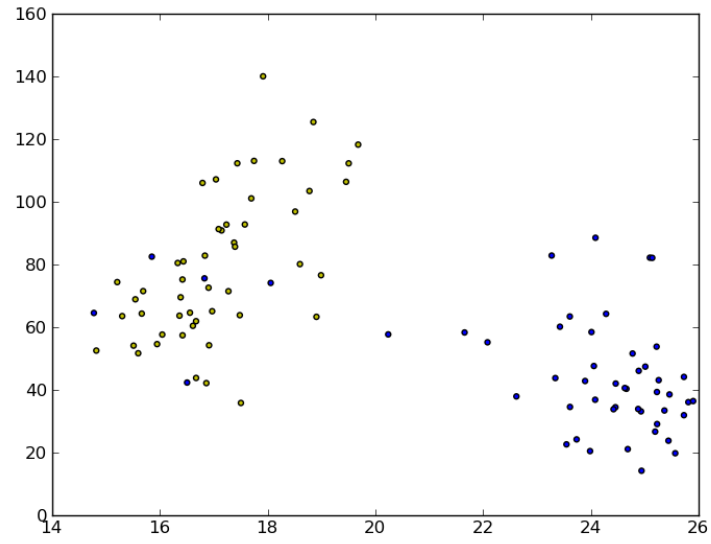
### 3.1 Scatter Plots

Below are a series of scatter plots showing the average values for Energy, Magnitude and ZCR across all 100 files. In each scatter diagram, the solid/blue plots represent speech files whereas the hollow/yellow plots represent silence files.

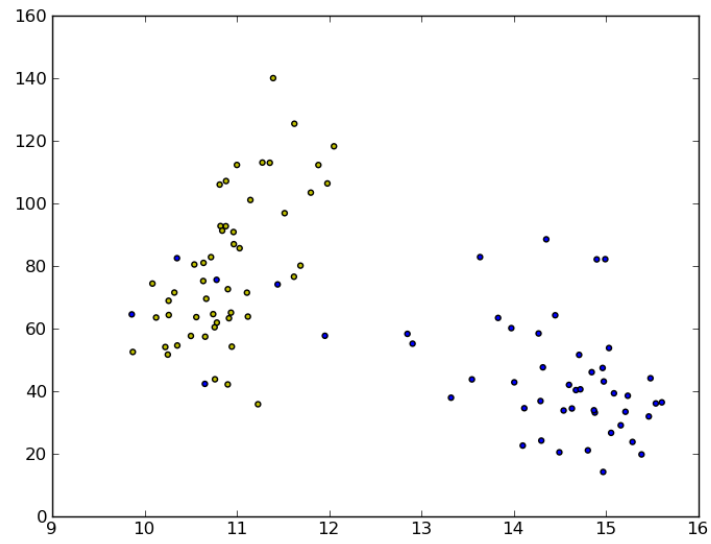
#### 3.1.1 Energy vs. Magnitude



### 3.1.2 Energy vs. ZCR



### 3.1.3 Magnitude vs. ZCR



## 3.2 Accuracy

Test Set	Percentage Accuracy
Test Set 1	100%
Test Set 2	100%
Test Set 3	90%
Test Set 4	90%
Test Set 5	90%
Test Set 6	90%
Test Set 7	100%
Test Set 8	80%
Test Set 9	100%
Test Set 10	100%

Table 1: Showing the accuracy of the system for each test set.

### 3.3 Guesses

The output of the system (specifically guesses) from the given input files are as follows. NB. The actual nature of the file should alternate between silence and speech (this is known due to the way in which files are read into the array and processed). For a list of how accurate each iteration is please refer to Section 3.2. In the following table, Test Set refers to the current test iteration and File Index is the index of the test file within the scope of the Test Set. To figure out which original file it will be

Test Set	File Index	Guess
0	0	SILENCE
0	1	SPEECH
0	2	SILENCE
0	3	SPEECH
0	4	SILENCE
0	5	SPEECH
0	6	SILENCE
0	7	SPEECH
0	8	SILENCE
0	9	SPEECH
1	0	SILENCE
1	1	SPEECH
1	2	SILENCE
1	3	SPEECH
1	4	SILENCE
1	5	SPEECH
1	6	SILENCE
1	7	SPEECH
1	8	SILENCE
1	9	SPEECH
2	0	SILENCE
2	1	SPEECH
2	2	SILENCE

2	3	SPEECH
2	4	SILENCE
2	5	SILENCE
2	6	SILENCE
2	7	SPEECH
2	8	SILENCE
2	9	SPEECH
3	0	SILENCE
3	1	SILENCE
3	2	SILENCE
3	3	SPEECH
3	4	SILENCE
3	5	SPEECH
3	6	SILENCE
3	7	SPEECH
3	8	SILENCE
3	9	SPEECH
4	0	SILENCE
4	1	SPEECH
4	2	SILENCE
4	3	SPEECH
4	4	SILENCE
4	5	SILENCE
4	6	SILENCE
4	7	SPEECH
4	8	SILENCE
4	9	SPEECH
5	0	SILENCE
5	1	SPEECH
5	2	SILENCE
5	3	SILENCE
5	4	SILENCE
5	5	SPEECH
5	6	SILENCE

5	7	SPEECH
5	8	SILENCE
5	9	SPEECH
6	0	SILENCE
6	1	SPEECH
6	2	SILENCE
6	3	SPEECH
6	4	SILENCE
6	5	SPEECH
6	6	SILENCE
6	7	SPEECH
6	8	SILENCE
6	9	SPEECH
7	0	SILENCE
7	1	SPEECH
7	2	SILENCE
7	3	SPEECH
7	4	SILENCE
7	5	SPEECH
7	6	SILENCE
7	7	SILENCE
7	8	SILENCE
7	9	SILENCE
8	0	SILENCE
8	1	SPEECH
8	2	SILENCE
8	3	SPEECH
8	4	SILENCE
8	5	SPEECH
8	6	SILENCE
8	7	SPEECH
8	8	SILENCE
8	9	SPEECH
9	0	SILENCE

9	1	SPEECH
9	2	SILENCE
9	3	SPEECH
9	4	SILENCE
9	5	SPEECH
9	6	SILENCE
9	7	SPEECH
9	8	SILENCE
9	9	SPEECH

## A Energy, Magnitude and Zero Crossing Rate Values

File Name	Energy	Magnitude	ZCR
Silence 01	14.8181905	9.87254156	0.10945486
Speech 01	25.7278583	15.4791513	0.09196527
Silence 02	19.6794362	12.0510437	0.24633420
Speech 02	24.0799154	14.2882048	0.07679079
Silence 03	17.2338339	10.8799228	0.19316753
Speech 03	23.2720036	13.6332829	0.17260590
Silence 04	16.9114331	10.9448033	0.11299218
Speech 04	25.5661937	15.3823123	0.04124305
Silence 05	16.5566494	10.7428855	0.13462673
Speech 05	25.0105956	14.9606998	0.09879687
Silence 06	15.6879689	10.3226940	0.14898177
Speech 06	25.0954392	14.9892010	0.17120486
Silence 07	16.9020396	10.9022325	0.15123437
Speech 07	25.8096398	15.5366163	0.07520225
Silence 08	16.3294857	10.5388733	0.16766840
Speech 08	23.5473281	14.0957821	0.04713975
Silence 09	17.4355984	11.0000529	0.23392447
Speech 09	21.6554115	12.8465678	0.12149652
Silence 10	16.4195716	10.6564329	0.11961111
Speech 10	25.3656362	15.2078305	0.06964583
Silence 11	17.1440381	10.9631978	0.18928993
Speech 11	25.2293984	15.1569760	0.06063194
Silence 12	16.6114123	10.7585950	0.12591232
Speech 12	23.6094617	13.8286941	0.13211111
Silence 13	17.3765088	10.9663581	0.18119791
Speech 13	15.8489268	10.3512895	0.17187065
Silence 14	16.3625413	10.5604384	0.13265017
Speech 14	23.9852958	14.4923011	0.04266579



Silence 15	15.5957817	10.2515114	0.10768402
Speech 15	24.7744232	14.7061652	0.10751822
Silence 16	18.9051003	10.9140038	0.13189322
Speech 16	16.8263386	10.7798552	0.15746093
Silence 17	17.3932031	11.0290752	0.17849479
Speech 17	24.4614966	14.5967193	0.08756076
Silence 18	15.9465617	10.3543602	0.11376388
Speech 18	23.6126359	14.1122809	0.07200347
Silence 19	17.5757934	10.8223510	0.19326649
Speech 19	22.0810845	12.9025026	0.11496961
Silence 20	17.6957142	11.1460381	0.21060069
Speech 20	24.0561433	14.3138539	0.09920659
Silence 21	16.9692450	10.9357291	0.13561197
Speech 21	24.9311564	14.8764534	0.06905729
Silence 22	17.4820635	11.1190428	0.13298697
Speech 22	24.4562097	14.6282134	0.07182378
Silence 23	16.4179296	10.6355416	0.15668315
Speech 23	16.5036239	10.6530943	0.08821267
Silence 24	16.4356727	10.6384729	0.16873437
Speech 24	24.0115100	14.2670987	0.12176736
Silence 25	18.5988868	11.6883026	0.16692100
Speech 25	23.7353901	14.2967662	0.05044010
Silence 26	16.8609959	10.9008553	0.08784288
Speech 26	23.3400119	13.5453021	0.09119270
Silence 27	17.0892137	10.8411649	0.19020138
Speech 27	20.2376603	11.9532454	0.12022569
Silence 28	19.5038903	11.8823899	0.23388281
Speech 28	25.7277238	15.4607995	0.06651822
Silence 29	16.6708021	10.7622438	0.09126996
Speech 29	24.2823496	14.4471676	0.13387586
Silence 30	16.6701659	10.7829497	0.12899305
Speech 30	24.9407110	14.9667514	0.02959288
Silence 31	17.7464385	11.2759219	0.23551736
Speech 31	24.8886605	14.8427144	0.09599565

Silence 32	15.6620026	10.2619129	0.13403906
Speech 32	25.1934854	15.0526787	0.05560503
Silence 33	18.8485759	11.6222199	0.26136111
Speech 33	25.4405116	15.2844281	0.04956597
Silence 34	15.5098995	10.2244129	0.11274565
Speech 34	24.0857221	14.3502382	0.18442795
Silence 35	15.5430064	10.2603319	0.14352690
Speech 35	24.8781547	14.8666565	0.07065017
Silence 36	16.8346293	10.7191943	0.17256423
Speech 36	25.2199826	15.0296811	0.11207465
Silence 37	18.7751966	11.8004094	0.21550173
Speech 37	24.6602339	14.6711315	0.0840625
Silence 38	17.5027746	11.2282560	0.07465277
Speech 38	23.4257651	13.9718581	0.12531163
Silence 39	18.5105591	11.5168204	0.20183246
Speech 39	14.7730310	9.86140434	0.13446354
Silence 40	16.3838741	10.6680383	0.14486371
Speech 40	18.0560317	11.4411074	0.15441493
Silence 41	15.2990479	10.1250974	0.13237239
Speech 41	22.6175322	13.3189989	0.07900347
Silence 42	16.7902125	10.8134292	0.22086458
Speech 42	25.8992214	15.6021272	0.07591319
Silence 43	18.2692975	11.3561345	0.23536979
Speech 43	24.4206929	14.5383240	0.07048784
Silence 44	17.0393628	10.8825532	0.22322135
Speech 44	25.1398304	14.8971795	0.17107638
Silence 45	15.2062666	10.0852154	0.15496701
Speech 45	24.6849800	14.8009195	0.04398090
Silence 46	17.2714316	11.1089300	0.14891579
Speech 46	23.8926520	14.0039271	0.08924565
Silence 47	17.9142265	11.3925960	0.29172482
Speech 47	24.6300962	14.7194521	0.08459201
Silence 48	18.9904911	11.6177766	0.15953559
Speech 48	25.2590496	14.9731213	0.0898125

Silence 49	16.0427867	10.5015867	0.12011111
Speech 49	25.4595605	15.2331701	0.08030729
Silence 50	19.4560825	11.9800991	0.22160763
Speech 50	25.2263110	15.0835968	0.08193836

## B Code

In order to see more detail in the solution, please uncomment the sections as advised in the code. The code requires numpy and matplotlib to be installed in order for the graphs to be shown.

```
import numpy
import math
import matplotlib.pyplot as plt
count = 1
import random

filename = ""

#Helper function
def toInt(x):
    return int(x)

#Helper function
def squares(x):
    return (x*x)

#Sign function for ZCR
def sign(x):
    if x >= 0:
        return 1
    else:
        return 0

#Helper function to calculate ZCR
def zcrFunc(theLines):
    i = 1
    theLines = [0] + map(sign, theLines)
    newvals = []
    while i < 2641:
        newvals.append(theLines[i] - theLines[i-1])
```

```

i = i + 1
newvals = map(abs, newvals)
return sums(newvals)

#Helper function
def toFloat(x):
return float(x)

#Helper sum function
def sums(ll):
i = 0
j = 240
listofsums = []
while (j < 2640):
listofsums.append(sum(ll[i:j]))
i = i + 1
j = j + 1
return listofsums

#Reads in files and calculates values of E, M and Z
def mainFunc(fileName):
f = open(fileName,'r')
lines = f.readlines()
intLines = [0]*240
intLines = intLines + map(toInt, lines)
energy_temp = map(squares, intLines)
magnitude_temp = map(abs, intLines)
Z = numpy.mean(zcrFunc(intLines))/480
E = math.log(numpy.mean(sums(energy_temp)))
M = math.log(numpy.mean(sums(magnitude_temp)))
listofenergy.append(E)
listofmags.append(M)
listofzcr.append(Z)
print fileName + "\tE: " + str(E)[0:10] + "\tM: " +
str(M)[0:10] + "\tZ: " + str(Z)[0:10]

```

```

#Breaks a list into k sub-lists
def foldbreak(k, list_x):
    endlist = []
    count = 100/k
    while (count < 110):
upper = count
lower = upper - (100/k)
endlist.append(list_x[lower:upper])
count += (100/k)
    return endlist

listofenergy = []
listofmags = []
listofzcr = []

print "\n"
while (count <= 50):
    if (count < 10):
filename1 = "silence_speech/silence_0" +
    str(count) + ".dat"
filename2 = "silence_speech/speech_0" +
    str(count) + ".dat"
    else:
filename1 = "silence_speech/silence_" +
    str(count) + ".dat"
filename2 = "silence_speech/speech_" +
    str(count) + ".dat"
    mainFunc(filename1)
    mainFunc(filename2)
    count += 1

count = 0
while (count < 100):

plt.figure(0)

```

```

plt.scatter(listofenergy[count],listofmags[count],s=10,c='y')
plt.scatter(listofenergy[count+1],listofmags[count+1],s=10,c='b')

plt.figure(1)
plt.scatter(listofenergy[count],listofzcr[count],s=10,c='y')
plt.scatter(listofenergy[count+1],listofzcr[count+1],s=10,c='b')

plt.figure(2)
plt.scatter(listofmags[count],listofzcr[count],s=10,c='y')
plt.scatter(listofmags[count+1],listofzcr[count+1],s=10,c='b')

count += 2
plt.show()

k = 10

#Breaks the array of 100 values into 2D array of 10 x 10
folded_energy = foldbreak(k,listofenergy)
folded_mags = foldbreak(k,listofmags)
folded_zcr = foldbreak(k,listofzcr)

#Function for calculating the variance
def getVariance(mean, trnset):
    count = 0
    variance_count = 0
    while (count < 45):
        variance_count += ((trnset[count] - mean) * (trnset[count] - mean))
        count += 1
    return variance_count/45

count = 0
while (count < 10):
    #The Test Sets

```

```

test_energy = folded_energy[count]
test_mags = folded_mags[count]
test_zcr = folded_zcr[count]

#The Training Sets
training_energy = []
training_mags = []
training_zcr = []
i = 0
while (i < 10):
    if (i == count):
        i += 1
    else:
        training_energy += folded_energy[i]
        training_mags += folded_mags[i]
        training_zcr += folded_zcr[i]
        i += 1

i = 0

#Splitting the Training Set into Speech and Silence sub sets
training_speech_energy = []
training_silence_energy = []
training_speech_mags = []
training_silence_mags = []
training_speech_zcr = []
training_silence_zcr = []

while (i < 90):
    training_silence_energy.append(training_energy[i])
    training_speech_energy.append(training_energy[i+1])
    training_silence_mags.append(training_mags[i])
    training_speech_mags.append(training_mags[i+1])
    training_silence_zcr.append(training_zcr[i])
    training_speech_zcr.append(training_zcr[i+1])
    i += 2

```



```

#Calculating the mean value
training_speech_mean_energy = numpy.mean(training_speech_energy)
training_silence_mean_energy = numpy.mean(training_silence_energy)
training_speech_mean_mags = numpy.mean(training_speech_mags)
training_silence_mean_mags = numpy.mean(training_silence_mags)
training_speech_mean_zcr = numpy.mean(training_speech_zcr)
training_silence_mean_zcr = numpy.mean(training_silence_zcr)

#Calculating the variance using custom getVariance function
train_speech_energy_var =
    getVariance(training_speech_mean_energy, training_speech_energy)
train_silence_energy_var =
    getVariance(training_silence_mean_energy,
training_silence_energy)
train_speech_mags_var =
    getVariance(training_speech_mean_mags, training_speech_mags)
train_silence_mags_var =
    getVariance(training_silence_mean_mags, training_silence_mags)
train_speech_zcr_var =
    getVariance(training_speech_mean_zcr, training_speech_zcr)
train_silence_zcr_var =
    getVariance(training_silence_mean_zcr, training_silence_zcr)

print "----- Test Iteration " + str(count) + "-----\n\n"

#Shows Mean and Variance Values, Uncomment if you
#Want this to be displayed as output

#print "training speech mean energy: " + str(training_speech_mean_energy)[:9] +
"\t\ttraining speech variance energy: " + str(train_speech_energy_var)[:9]
#print "training silence mean energy: " + str(training_silence_mean_energy)[:9] +
"\t\ttraining silence variance energy: " + str(train_silence_energy_var)[:9] + "\n"

#print "training speech mean mags: " + str(training_speech_mean_mags)[:9]

```

```

    + "\t\ttraining speech variance mags: " + str(train_speech_mags_var)[:9]
#print "training silence mean mags: " + str(training_silence_mean_mags)[:9]
    + "\t\ttraining silence variance mags: " + str(train_silence_mags_var)[:9] + "\n"

#print "training speech mean zcr: " + str(training_speech_mean_zcr)[:9]
    + "\t\ttraining speech variance zcr: " + str(train_speech_zcr_var)[:9]
#print "training silence mean zcr: " + str(training_silence_mean_zcr)[:9]
    + "\t\ttraining silence variance zcr: " + str(train_silence_zcr_var)[:9] + "\n"

i = 0;

while (i < 10):

test_val_e = test_energy[i]
test_val_m = test_mags[i]
test_val_z = test_zcr[i]
pi = math.pi

#Calculate probabilities for Energy
prob_sil_energy = (1/math.sqrt(2 * pi *
train_silence_energy_var))*((math.exp(-(test_val_e -
training_silence_mean_energy)**2))/(2*train_silence_energy_var))
prob_speech_energy = (1/math.sqrt(2 * pi *
train_speech_energy_var))*((math.exp(-(test_val_e -
training_speech_mean_energy)**2))/(2*train_speech_energy_var))

#Calculate probabilities for Magnitude
prob_sil_mags = (1/math.sqrt(2 * pi *
train_silence_mags_var))*((math.exp(-(test_val_m -
training_silence_mean_mags)**2))/(2*train_silence_mags_var))
prob_speech_mags = (1/math.sqrt(2 * pi *
train_speech_mags_var))*((math.exp(-(test_val_m -
training_speech_mean_mags)**2))/(2*train_speech_mags_var))

#Calculate probabilities for ZCR

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prob_sil_zcr = (1/math.sqrt(2 * pi * train_silence_zcr_var))*
((math.exp(-(test_val_z
- training_silence_mean_zcr)**2))/(2*train_silence_zcr_var))

prob_speech_zcr = (1/math.sqrt(2 * pi * train_speech_zcr_var))*
((math.exp(-(test_val_z -
training_speech_mean_zcr)**2))/(2*train_speech_zcr_var))

#Calculate OVERALL probability
prob_sil = prob_sil_energy * prob_sil_mags * prob_sil_zcr
prob_speech = prob_speech_energy * prob_speech_mags * prob_speech_zcr

#Prints probability values, uncomment if you
#would like to see the values

#print "Probability silence based on energy: " + str(prob_sil_energy)
#print "Probability speech based on energy: " + str(prob_speech_energy)
#print "Probability silence based on magnitude: " + str(prob_sil_mags)
#print "Probability speech based on magnitude: " + str(prob_speech_mags)
#if (prob_sil_zcr == 0):
# print "Probability silence based on zcr too small to calculate"
#else:
# print "Probability silence based on zcr: " + str(prob_sil_zcr)
#if (prob_speech_zcr == 0):
# print "Probability speech based on zcr too small to calculate"
#else:
# print "Probability speech based on zcr: " + str(prob_speech_zcr)

energy_guess = ""
mags_guess = ""
zcr_guess = ""
final_guess = ""

#ENERGY
if (prob_speech_energy > prob_sil_energy):
energy_guess = "speech"

```

```

elif (prob_sil_energy > prob_speech_energy):
    energy_guess = "silence"
else:
    energy_guess = "unknown"

#Guess based solely on ENERGY.
#print "Guess for ENERGY \t" + str(count) + "-" + str(i) + " is \t" +
energy_guess.upper()

#MAGNITUDE
if (prob_speech_mags > prob_sil_mags):
    mags_guess = "speech"
elif (prob_sil_mags > prob_speech_mags):
    mags_guess = "silence"
else:
    mags_guess = "unknown"
#Guess based solely on MAGNITUDE.
#print "Guess for MAGNITUDE \t" + str(count) + "-" + str(i) + " is \t" +
mags_guess.upper()

#ZCR
if (prob_speech_zcr > prob_sil_zcr):
    zcr_guess = "speech"
elif (prob_sil_zcr > prob_speech_zcr):
    zcr_guess = "silence"
else:
    zcr_guess = "unknown"
#Guess based solely on ZCR.
#print "Guess for ZCR \t\t" + str(count) + "-" + str(i) + " is \t" +
zcr_guess.upper()

#FINAL
if (prob_speech > prob_sil):
    final_guess = "speech"
elif (prob_sil > prob_speech):
    final_guess = "silence"

```

```
else:
    final_guess = "unknown"
    print "Final Guess is \t\t" + str(count) + "-" + str(i) + " is \t" +
    final_guess.upper() + "\n"
    i += 1
    count += 1
```