Speaker Signals Recognition

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EECE 5356 – Digital Signal Processing

I. Overview

We built:

main.m – big script contain all the helper functions. Run main.m by *Run sections*, not full script, to get what we want.

createDatabase.m – create a matrix that concatenates training signals of 1 subject.

Input: NONE, but user have to choose folder with all voice signals of a subject when prompted.

Output: train matrix of that subject.

processVoice.m – Do all the Fourier transform, spectrogram, and normalization for 1 signal.

Input: file name for voice signal of 1 subject

Output: processed signal of 1 subject

calcScore.m – calculate the difference score between a voice signal and a voice matrix of 1 subject

Input: 1 unknown signal, 1 train matrix of a subject

Output: difference score

classify.m – classify sound signals of unknown subject in train set.
Input: a) All train matrices b) folder of unknown subject to classify

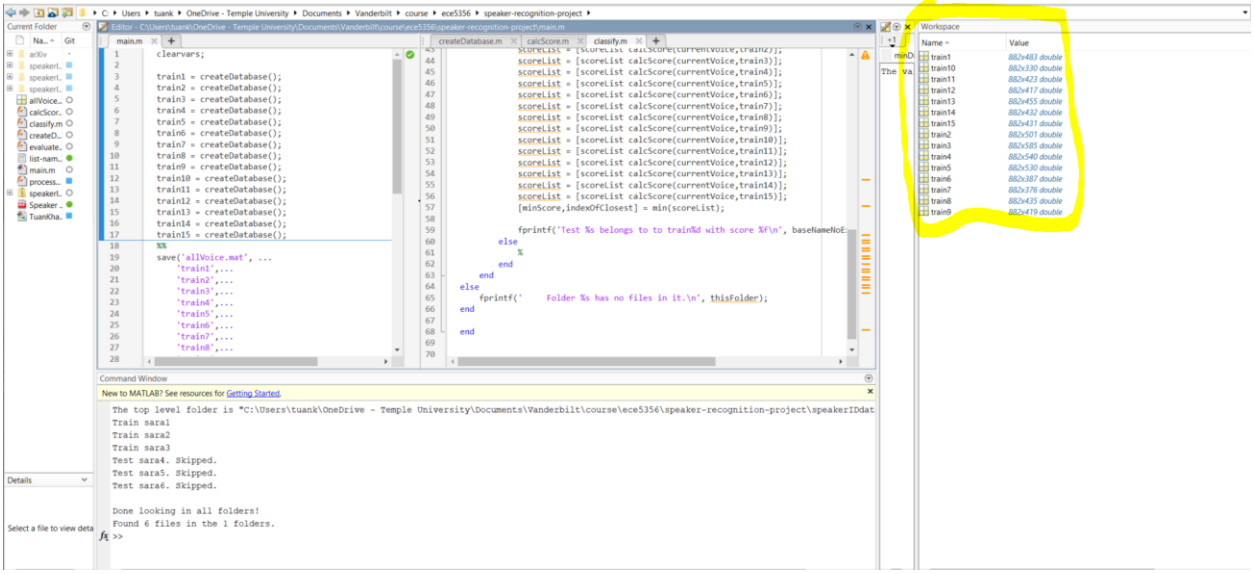
Output: Classification + score of each file.

classifyUnknown.m – similar to classify.m but for unknown subjects NOT in train set.

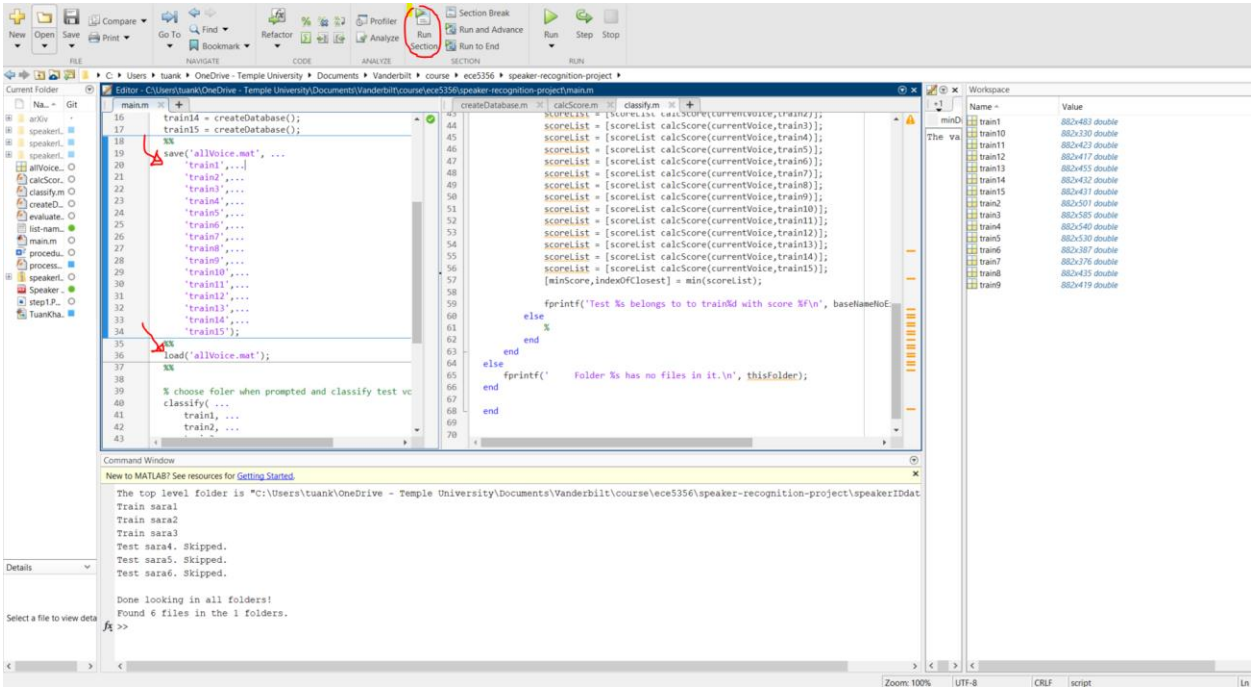
We design it this way since voice signals do not have the same lengths which did not allow concatenation / grouping of all processed voices into 1 big matrix. Every subject has their own training matrix.

II. Classify unknowns of subjects included in train set.

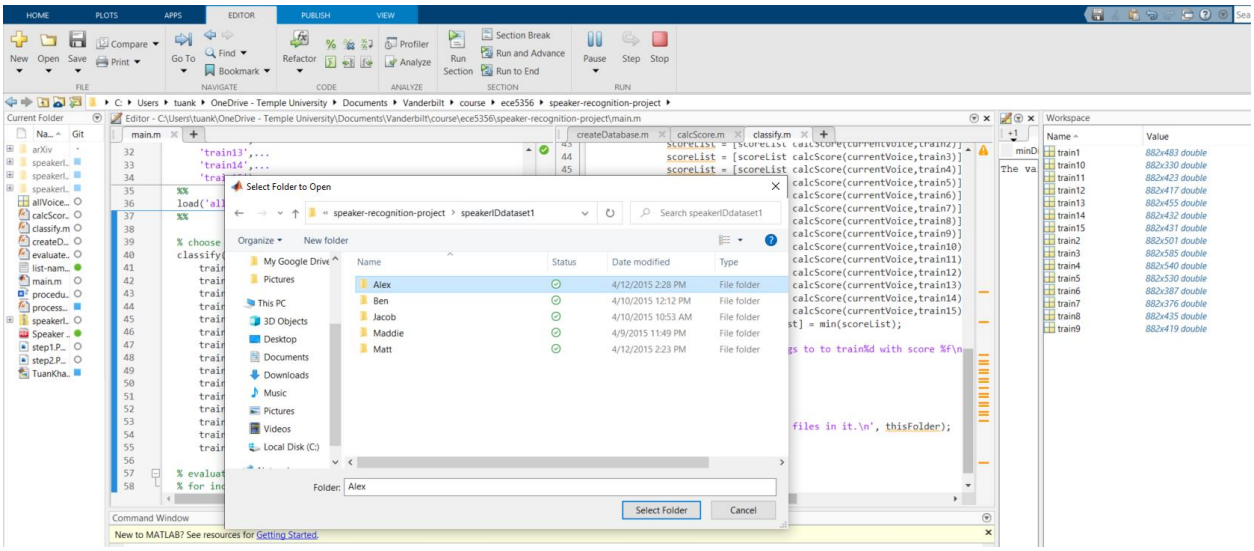
Step 1: Run first section of **main.m** to get all training matrices. We have 15 training subjects so 15 matrices to be obtained:



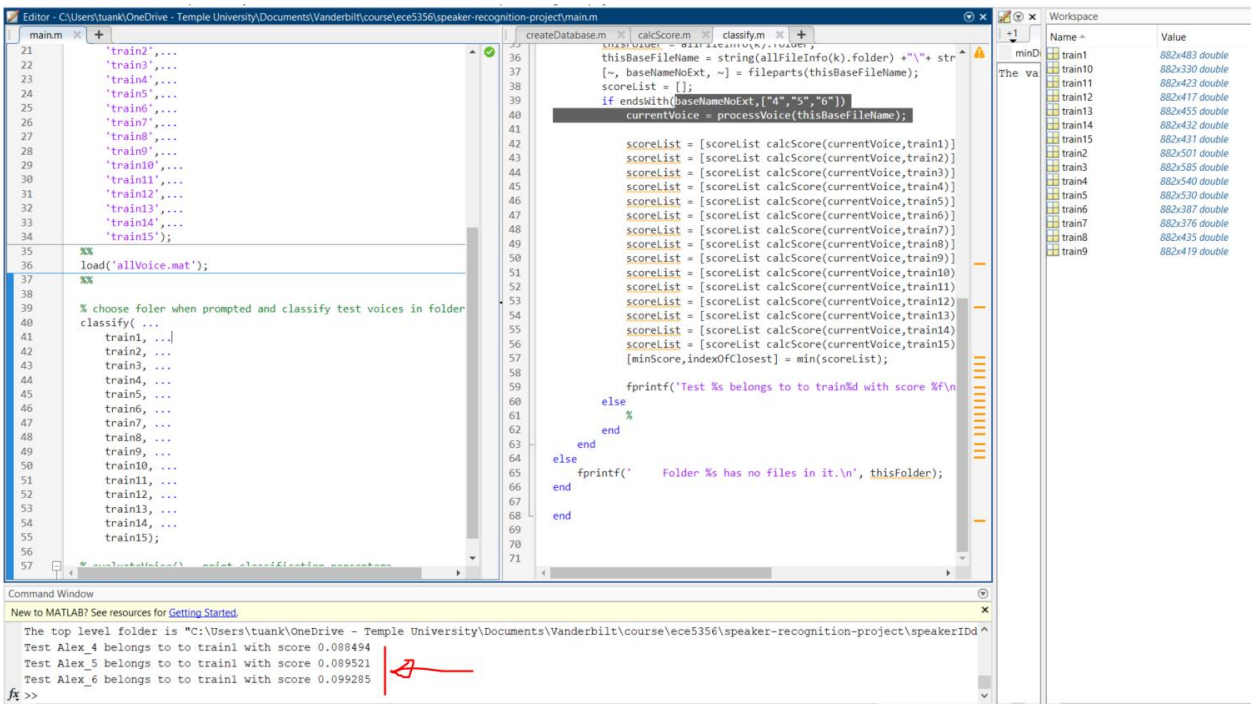
Step 2: We can save training data and reload for future use. Run the next section of **main.m**:



Step 3: Run the 'classify' section in **main.m,** which calls **classify.m** and prompts user to pick a folder containing the '.wav' files.



When chosen, **classify.m** will (1) pick out the files used for testing, (2) compute the difference score against all 15 training matrices (3) Print out which training set/matrix it belongs to:



We did the same for all other folders, results are shown below:

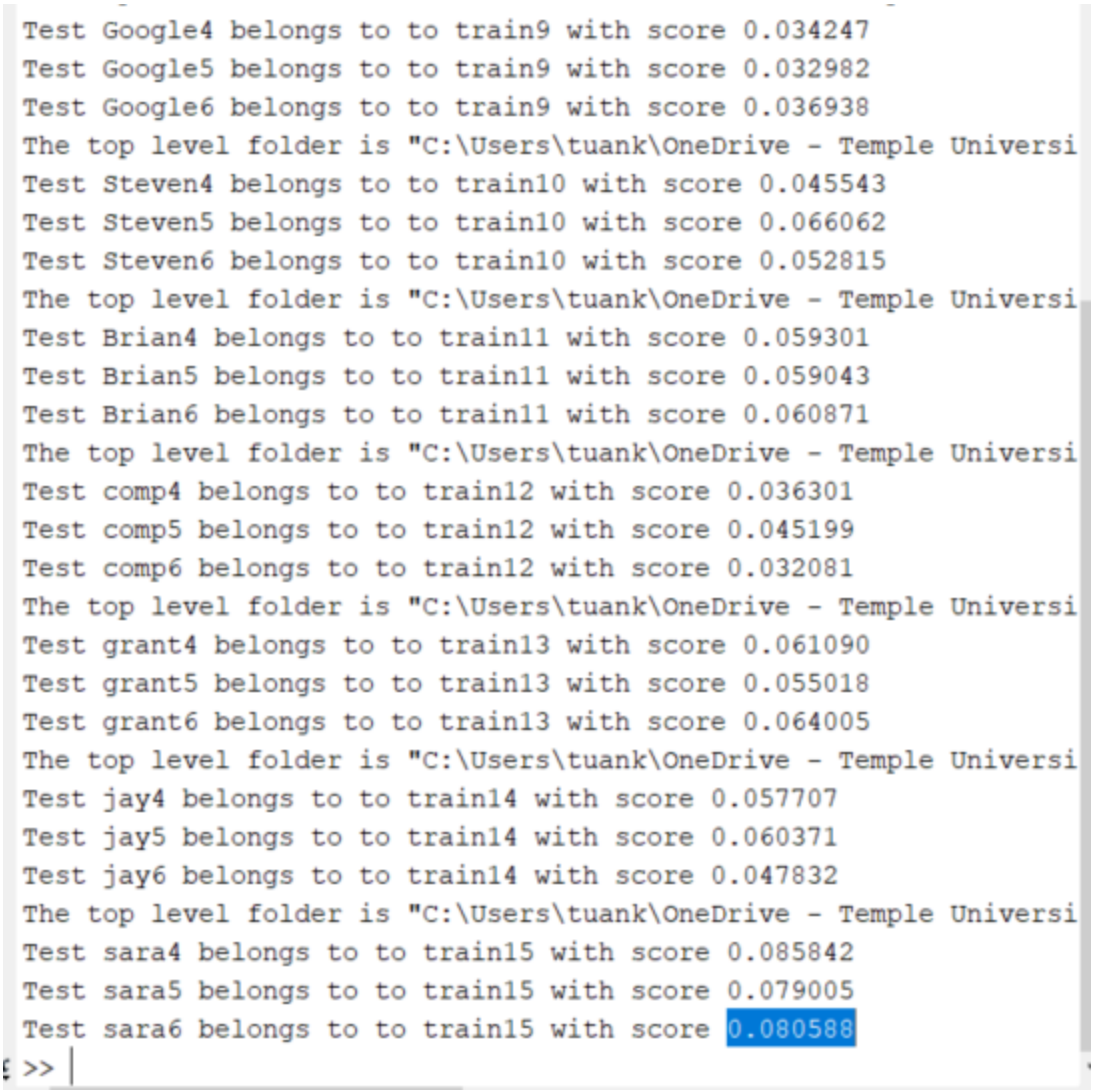
Filename	Class/score	Filename	Class/score	Filename	Class/score
Alex4	Alex(train1)/ 0.088494	Ben4	Ben(train2)/ 0.080054	Jacob4	Jacob(train3)/ 0.121352
Alex5	Alex(train1)/ 0.089521	Ben5	Ben(train2)/ 0.084463	Jacob5	Jacob(train3)/ 0.125160

Alex6	Alex(train1)/ 0.099285	Ben6	Ben(train2)/ 0.070069	Jacob6	Jacob(train3)/ 0.111311
Maddie4	Maddie(train4)/ 0.103010	Matt4	Matt(train5)/ 0.086573	Akash4	Akash (train6)/ 0.047665
Maddie5	Maddie(train4)/ 0.104005	Matt5	Matt(train5)/ 0.095349	Akash5	Akash (train6)/ 0.046104
Maddie6	Maddie(train4)/ 0.114670	Matt6	Matt(train5)/ 0.089152	Akash6	Akash (train6)/ 0.047501
Daniel4	Daniel(train7)/ 0.065633	Eliza4	Eliza(train8)/ 0.067229	Google4	Google(train9)/ 0.034247
Daniel5	Daniel(train7)/ 0.062741	Eliza5	Eliza(train8)/ 0.085958	Google5	Google(train9)/ 0.032982
Daniel6	Daniel(train7)/ 0.072744	Eliza6	Eliza(train8)/ 0.069994	Google6	Google(train9)/ 0.036938
Steven4	Steven(train10)/ 0.045543	Brian4	Brian(train11)/ 0.059301	Comp4	Comp(train12)/ 0.036301
Steven5	Steven(train10)/ 0.066062	Brian5	Brian(train11)/ 0.059043	Comp5	Comp(train12)/ 0.045199
Steven6	Steven(train10)/ 0.052815	Brian6	Brian(train11)/ 0.060871	Comp6	Comp(train12)/ 0.032081
Grant4	Grant(train13)/ 0.061090	Jay4	Jay(train14)/ 0.057707	Sara4	Sara(train15)/ 0.085842
Grant5	Grant(train13)/ 0.055018	Jay5	Jay(train14)/ 0.060371	Sara5	Sara(train15)/ 0.079005
Grant6	Grant(train13)/ 0.064005	Jay6	Jay(train14)/ 0.047832	Sara6	Sara(train15)/ 0.080588

Full log is displayed here:

(I went to Temple before Vanderbilt so the Temple OneDrive folder)

```
The top level folder is "C:\Users\tuank\OneDrive - Temple Universi
Test Alex_4 belongs to to train1 with score 0.088494
Test Alex_5 belongs to to train1 with score 0.089521
Test Alex_6 belongs to to train1 with score 0.099285
The top level folder is "C:\Users\tuank\OneDrive - Temple Universi
Test Ben_4 belongs to to train2 with score 0.080054
Test Ben_5 belongs to to train2 with score 0.084463
Test Ben_6 belongs to to train2 with score 0.070069
The top level folder is "C:\Users\tuank\OneDrive - Temple Universi
Test Jacob_4 belongs to to train3 with score 0.121352
Test Jacob_5 belongs to to train3 with score 0.125160
Test Jacob_6 belongs to to train3 with score 0.111311
>>
The top level folder is "C:\Users\tuank\OneDrive - Temple Universi
Test Maddie_4 belongs to to train4 with score 0.103010
Test Maddie_5 belongs to to train4 with score 0.104005
Test Maddie_6 belongs to to train4 with score 0.114670
The top level folder is "C:\Users\tuank\OneDrive - Temple Universi
Test Matt_4 belongs to to train5 with score 0.086573
Test Matt_5 belongs to to train5 with score 0.095349
Test Matt_6 belongs to to train5 with score 0.089152
The top level folder is "C:\Users\tuank\OneDrive - Temple Universi
Test Akash4 belongs to to train6 with score 0.047665
Test Akash5 belongs to to train6 with score 0.046104
Test Akash6 belongs to to train6 with score 0.047501
The top level folder is "C:\Users\tuank\OneDrive - Temple Universi
Test Daniel4 belongs to to train7 with score 0.065633
Test Daniel5 belongs to to train7 with score 0.062741
Test Daniel6 belongs to to train7 with score 0.072744
The top level folder is "C:\Users\tuank\OneDrive - Temple Universi
Test Eliza4 belongs to to train8 with score 0.067229
Test Eliza5 belongs to to train8 with score 0.085958
Test Eliza6 belongs to to train8 with score 0.069994
The top level folder is "C:\Users\tuank\OneDrive - Temple Universi
Test Google4 belongs to to train9 with score 0.034247
```



III. Classify unknowns of subjects NOT included in train set.

Some initial experiments show that our classification method from **part I.** produces relatively consistent results on which train set where subjects, NOT coming from the train set, are the closest to, except for the variance for DavidR.

We can come up with a simple way that make use of the scoring function developed from part I.

Alex (train1)	0.092433± 0.005956	Ben (train2)	0.078195± 0.007375	Jacob (train3)	0.119274± 0.007155
Maddie (train4)	0.107228± 0.006464	Matt (train5)	0.090358± 0.004511	Akash (train6)	0.047090± 0.000858
Daniel (train7)	0.067039± 0.005148	Eliza (train8)	0.074394± 0.010110	Google (train9)	0.034723± 0.002020
Steven (train10)	0.054807± 0.010404	Brian (train11)	0.059739± 0.000990	Comp (train12)	0.037860± 0.006696
Grant (train13)	0.060038± 0.004585	Jay (train14)	0.055303± 0.006606	Sara (train15)	0.081812± 0.003579

The table shows the mean and standard deviation of the score of 3 test samples from part 1 computed against their respective train matrix. For example, jay4, jay5, jay6 has a mean score of 0.055303 and standard deviation 0.006606 to the big Jay train matrix, as shown in table.

Thus, alternatively, we can view **a score** as the **distance** from the center of a cluster (ex: Jay) to a point of voice sound. This distance has the mean and standard deviation of the score. This distance (with standard deviation) can be viewed as a radius of a sphere representing the cluster if we choose to visualize in 3D but it can be at higher dimensions.

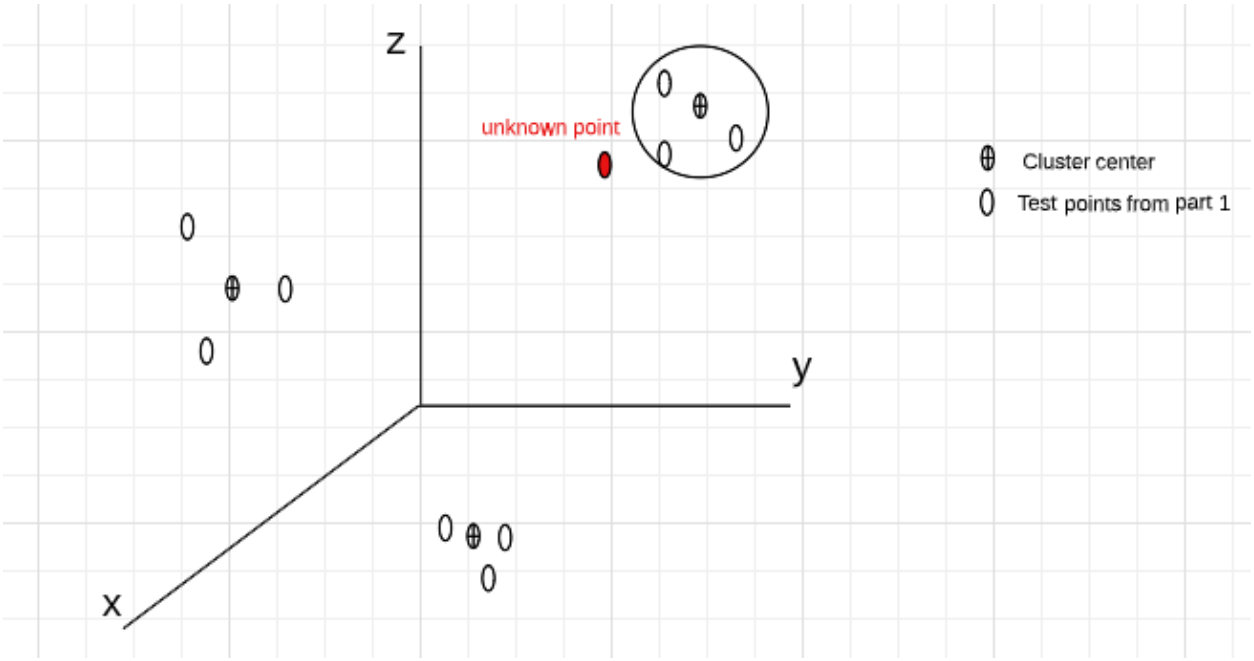


Figure 1. Simple illustration of distance-from-cluster-center idea.

1. So we can reuse the **score** function, determine the minimum score and assign it to a train set. This score will be the distance of the point to the center of the train set.
2. Run the section in from **main.m** with classifyUnknown to get the scores for unknown sounds in speakerDataSet7.

3. Then, we check if it is within the radius of the sphere i.e. belongs to the cluster, using the mean and standard deviation of the distance from each cluster's center (from the table above).

We try out with WillR's, which the algorithm from part 1 classifies them to belong to Jay cluster.

```
Test WillR1 belongs to to train14 with score 0.069054
Test WillR2 belongs to to train14 with score 0.062083
Test WillR3 belongs to to train14 with score 0.059400
Test WillR4 belongs to to train14 with score 0.062403
Test WillR5 belongs to to train14 with score 0.061385
Test WillR6 belongs to to train14 with score 0.057387
```

Figure 2. We have 50% of these scores are inside Jay's cluster (train14) with radius 0.055303 ± 0.006606 = [0.048697 0.061909]. Accuracy 50%

Results for other subjects and accuracy of classifying whether it belongs to the cluster is shown below:

```
Test DavidL1 belongs to to train14 with score 0.081652
Test DavidL2 belongs to to train14 with score 0.067163
Test DavidL3 belongs to to train14 with score 0.067524
Test DavidL4 belongs to to train14 with score 0.071634
Test DavidL5 belongs to to train14 with score 0.067569
Test DavidL6 belongs to to train14 with score 0.069029
```

Figure 3. We have NONE of these scores are inside 0.055303 ± 0.006606 = [0.048697 0.061909]. So all are outside of Jay's cluster (train14). Accuracy 100%

```
Test BrandiC1 belongs to to train8 with score 0.105219
Test BrandiC2 belongs to to train8 with score 0.098107
Test BrandiC3 belongs to to train8 with score 0.106954
Test BrandiC4 belongs to to train8 with score 0.094350
Test BrandiC5 belongs to to train8 with score 0.089878
Test BrandiC6 belongs to to train8 with score 0.085990
```

Figure 4. BrandiC got classified as belonging to Eliza (train8), radius 0.074394 ± 0.010110 = [0.064248 0.084504]. So NONE of BrandiC sounds are inside the sphere. Accuracy 100%.

```
Test ErinL1 belongs to to train8 with score 0.092700
Test ErinL2 belongs to to train8 with score 0.092875
Test ErinL3 belongs to to train8 with score 0.090152
Test ErinL4 belongs to to train8 with score 0.079122
Test ErinL5 belongs to to train8 with score 0.087649
Test ErinL6 belongs to to train8 with score 0.082004
```

Figure 5. ErinL classified as belonging to Eliza (train8), radius 0.074394 ± 0.010110 = [0.064248 0.084504]. So 2 of ErinL sounds are inside the sphere. Accuracy 66.6%.

```
Test DavidR1 belongs to to train14 with score 0.087115
Test DavidR2 belongs to to train13 with score 0.087557
Test DavidR3 belongs to to train13 with score 0.086772
Test DavidR4 belongs to to train13 with score 0.084373
Test DavidR5 belongs to to train13 with score 0.081351
Test DavidR6 belongs to to train14 with score 0.082727
```

Figure 6. DavidR classified as belonging to Grant (train13) radius 0.060038 ± 0.004585, with max radius **0.064623** and Jay (train14) radius 0.055303 ± 0.006606 with max radius **0.061909**. So NONE of DavidR sounds are inside any of these 2 spheres. Accuracy 100%.