TUGAS 2 PEMROSESAN UCAPAN

SISTEM PENGENALAN UCAPAN MENGGUNAKAN DYNAMIC TIME WARPING (DTW)

OLEH :

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OBJEKTIF TUGAS

- Membuat sistem pengenalan ucapan dengan menggunakan Dynamic Time Warping (DTW)
- Memproses ekstraksi fitur berdasarkan suara template huruf vokal dengan MFCC 39 dimensi
- Memproses suara testing untuk kelima huruf vokal dan mendapatkan hasil jarak beserta akurasi dengan menggunakan DTW

METODOLOGI

ALUR METODOLOGI

PENCARIAN DISTANCE UNTUK TIAP AUDIO

1. Melakukan pemilihan terhadap sumber audio template dan audio test
2. Memproses ekstraksi suara untuk tiap audio dalam folder yang dipilih dengan fungsi ekstraksi MFCC 39 dimensi
3. Melakukan perhitungan jarak (distance) untuk membandingkan audio template dengan audio test pada huruf yang sama dengan fungsi DTW
4. Sorting terhadap hasil perbandingan distance berdasarkan jarak terkecil hingga jarak terbesar
5. Menghitung rata-rata hasil perbandingan untuk setiap huruf mulai dari A hingga O
6. Menghitung rata-rata keseluruhan berdasarkan setiap hasil perbandingan

ALUR METODOLOGI

PENCARIAN AKURASI KECOCOKAN SUARA

1. Melakukan pemilihan terhadap sumber audio template dan audio test
2. Memproses ekstraksi suara untuk tiap audio dalam folder yang dipilih dengan fungsi ekstraksi MFCC 39 dimensi
3. Melakukan perhitungan jarak (distance) untuk membandingkan audio template dengan audio test untuk seluruh huruf dengan fungsi DTW
4. Sorting terhadap hasil perbandingan distance berdasarkan jarak terkecil hingga jarak terbesar
5. Mencari kecocokan terhadap perbandingan audio, jika audio template dengan audio test pada huruf vokal yang sama memiliki jarak terkecil, audio akan dihitung cocok
6. Menghitung persentase kecocokan dengan membagi antara audio huruf vokal yang cocok dengan keseluruhan huruf vokal yang ada mulai dari A-O

1. Feature Extraction (MFCC)

```python
import scipy.io.wavfile as wav
from python_speech_features import mfcc

# Function to extract MFCC features using python_speech_features
def extract_mfcc(file_path):
    # Load the audio file
    rate, sig = wav.read(file_path)

    # Extract MFCC features with increased NFFT to avoid warning
    mfcc_feat = mfcc(sig, rate, nfft=2048)  # Increased NFFT size to avoid truncation warning
    return mfcc_feat
```

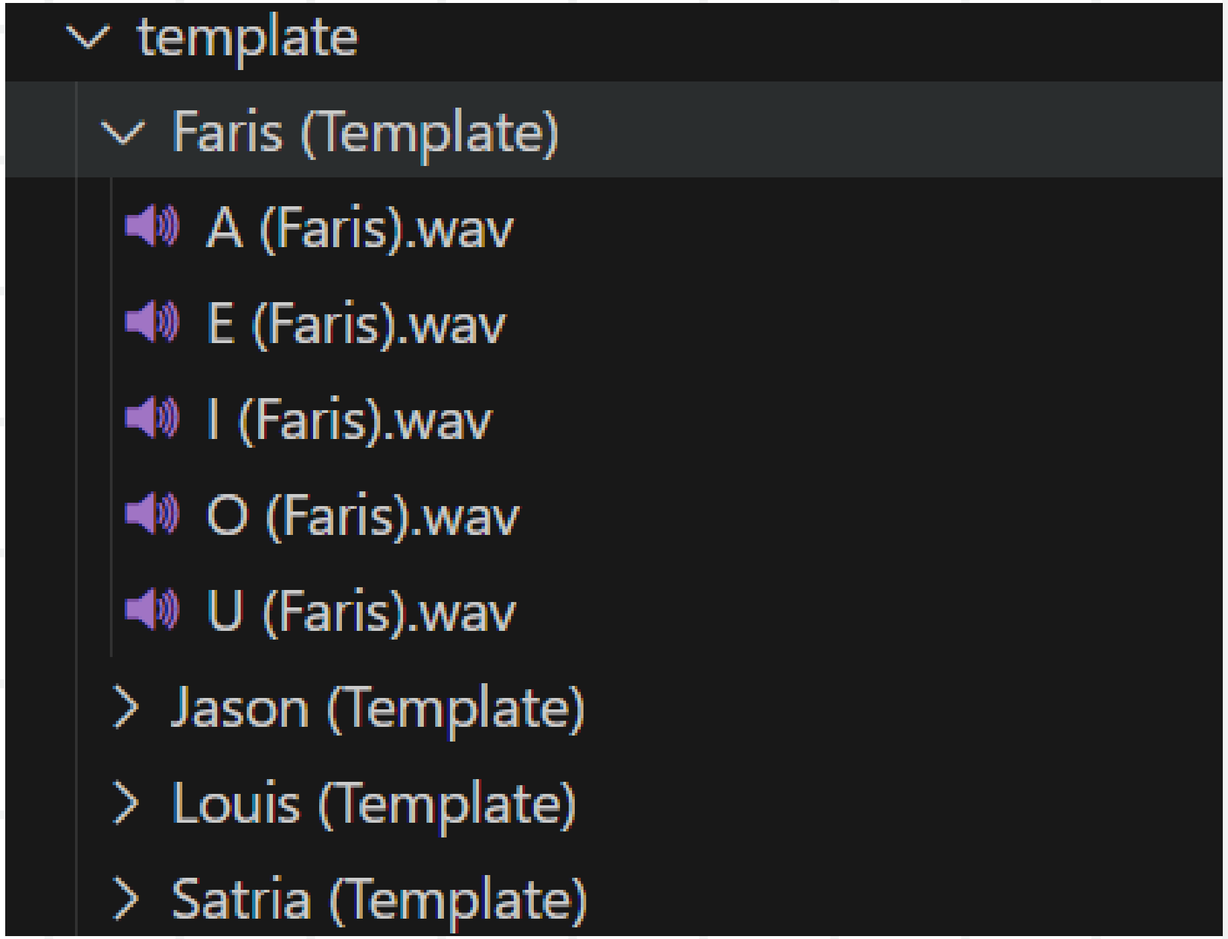
Fungsi ini membaca file audio dalam format .wav, kemudian mengekstrak fitur MFCC dari sinyal suara tersebut dengan mempertimbangkan sampling rate dan ukuran NFFT untuk resolusi frekuensi yang lebih baik. Fitur MFCC yang dihasilkan dapat digunakan dalam analisis lebih lanjut, seperti klasifikasi suara atau pengenalan pola akustik.

2. Dynamic Time Warping (DTW)

```python
import numpy as np
from scipy.spatial.distance import cdist

# Dynamic Time Warping (DTW) function to calculate similarity between two feature sets
def dtw(x, y, dist_func='euclidean'):
    cost = cdist(x, y, metric=dist_func)
    # Create a cumulative cost matrix
    acc_cost = np.zeros_like(cost)
    acc_cost[0, 0] = cost[0, 0]

    # Initialize the edges
    for i in range(1, acc_cost.shape[0]):
        acc_cost[i, 0] = cost[i, 0] + acc_cost[i - 1, 0]
    for j in range(1, acc_cost.shape[1]):
        acc_cost[0, j] = cost[0, j] + acc_cost[0, j - 1]

    # Populate the cumulative cost matrix
    for i in range(1, acc_cost.shape[0]):
        for j in range(1, acc_cost.shape[1]):
            acc_cost[i, j] = cost[i, j] + min(acc_cost[i - 1, j],
                                              acc_cost[i, j - 1],
                                              acc_cost[i - 1, j - 1])

    return acc_cost[-1, -1]  # Return the final cost (similarity score)
```

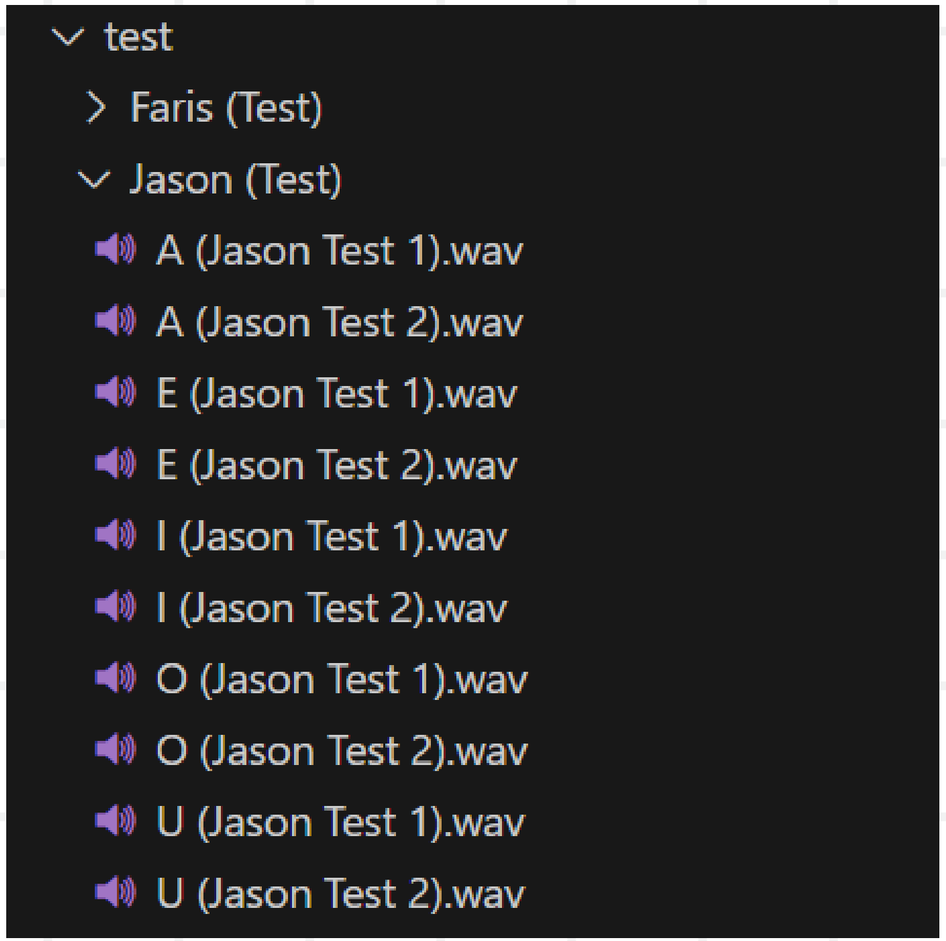
Algoritma DTW memungkinkan pencocokan urutan yang mungkin memiliki perbedaan dalam waktu atau kecepatan. Hasil akhir adalah nilai yang menunjukkan seberapa mirip dua urutan tersebut, dengan mempertimbangkan perbedaan waktu.

3. Template Recording Audio



Audio template merupakan audio sampel yang digunakan sebagai data awal dari dictionary suara pada masing-masing individu. Audio template terdiri atas suara yang direkam oleh 4 orang yang berbeda untuk keseluruhan huruf vokal mulai dari A, I, U, E, dan O.

4. Test Recording Audio



Audio testing merupakan audio yang akan digunakan sebagai audio pengujian untuk dibandingkan dengan audio template yang merupakan dictionary awal. Audio template terdiri atas suara yang direkam oleh 4 orang yang berbeda untuk keseluruhan huruf vokal mulai dari A, I, U, E, dan O dan untuk setiap huruf, terdapat 2 test case sehingga untuk setiap orang, terdapat 10 audio untuk test.

PENGUJIAN

SKENARIO PENGUJIAN

DEPENDENT

Template masing-masing vowel akan diuji dengan Test Case pada orang yang sama. Misalnya, Template A Jason diuji terhadap Test A Jason 1 dan Test A Jason 2

INDEPENDENT

Template masing-masing vowel akan diuji dengan Test Case pada orang yang berbeda. Misalnya, Template A Jason diuji terhadap Test A Louis 1, Test A Satria 2, dan Test A Faris 1

PEMILIHAN OPSI PENGUJIAN

```
Current directory: d:\JASON\Kuliah\Matkul\Semester 7\Pemrosesan Ucapan\Tugas 2\IF4071_DTW\src
Pilih opsi:
1. Melakukan perhitungan jarak antara file audio
2. Menghitung akurasi total
Masukkan pilihan Anda (1/2):
```

PEMILIHAN FOLDER
AUDIO TEMPLATE & TEST

```
(1) Pilih folder dalam template untuk audio input

Pilih folder audio file:
1. Faris (Template)
2. Jason (Template)
3. Louis (Template)
4. Satria (Template)

Masukkan pilihan dengan angka: 2

Folder yang dipilih: Jason (Template)
File .wav yang tersedia di folder ini:
1. A (Jason).wav
2. E (Jason).wav
3. I (Jason).wav
4. O (Jason).wav
5. U (Jason).wav

Daftar file yang tersedia di folder sound input:
['A (Jason).wav', 'E (Jason).wav', 'I (Jason).wav', 'O (Jason).wav',
 'U (Jason).wav']
```

```
(2) Pilih folder dalam test untuk audio yang akan dibandingkan

Pilih folder audio file:
1. Faris (Test)
2. Jason (Test)
3. Louis (Test)
4. Satria (Test)

Masukkan pilihan dengan angka: 2

Folder yang dipilih: Jason (Test)
File .wav yang tersedia di folder ini:
1. A (Jason Test 1).wav
2. A (Jason Test 2).wav
3. E (Jason Test 1).wav
4. E (Jason Test 2).wav
5. I (Jason Test 1).wav
6. I (Jason Test 2).wav
7. O (Jason Test 1).wav
8. O (Jason Test 2).wav
9. U (Jason Test 1).wav
10. U (Jason Test 2).wav

Daftar file yang tersedia di sound compare:
['A (Jason Test 1).wav', 'A (Jason Test 2).wav', 'E (Jason Test 1).wav',
 'E (Jason Test 2).wav', 'I (Jason Test 1).wav', 'I (Jason Test 2).wav',
 'O (Jason Test 1).wav', 'O (Jason Test 2).wav', 'U (Jason Test 1).wav',
 'U (Jason Test 2).wav']
```

PENGUJIAN PENCARIAN DISTANCE

```
MENAMPILKAN INFORMASI PERBANDINGAN SUARA:

Voice files for vowel 'A':
Template files: [A (Jason).wav, E (Jason).wav, I (Jason).wav, O (Jason).wav, U (Jason).wav]
Test files: [A (Jason Test 1).wav, A (Jason Test 2).wav]

Hasil perbandingan file audio:
1. Sound between A (Jason Test 2).wav and A (Jason).wav have 6113.72178332679 distance
2. Sound between A (Jason Test 1).wav and A (Jason).wav have 15743.361196984853 distance
Jarak rata-rata untuk vokal 'A': 10928.541490155822



Voice files for vowel 'E':
Template files: [A (Jason).wav, E (Jason).wav, I (Jason).wav, O (Jason).wav, U (Jason).wav]
Test files: [E (Jason Test 1).wav, E (Jason Test 2).wav]

Hasil perbandingan file audio:
1. Sound between E (Jason Test 2).wav and E (Jason).wav have 20345.300565873127 distance
2. Sound between E (Jason Test 1).wav and E (Jason).wav have 20820.16940481416 distance
```

```
Voice files for vowel 'I':
Template files: [A (Jason).wav, E (Jason).wav, I (Jason).wav, O (Jason).wav, U (Jason).wav]
Test files: [I (Jason Test 1).wav, I (Jason Test 2).wav]

Hasil perbandingan file audio:
1. Sound between I (Jason Test 1).wav and I (Jason).wav have 9192.782612653371 distance
2. Sound between I (Jason Test 2).wav and I (Jason).wav have 21310.616255711688 distance
Jarak rata-rata untuk vokal 'I': 15251.65943418249



Voice files for vowel 'O':
Template files: [A (Jason).wav, E (Jason).wav, I (Jason).wav, O (Jason).wav, U (Jason).wav]
Test files: [O (Jason Test 1).wav, O (Jason Test 2).wav]

Hasil perbandingan file audio:
1. Sound between O (Jason Test 2).wav and O (Jason).wav have 19525.784077269713 distance
2. Sound between O (Jason Test 1).wav and O (Jason).wav have 20859.74089988221 distance
Jarak rata-rata untuk vokal 'O': 20192.76688857596



Voice files for vowel 'U':
Template files: [A (Jason).wav, E (Jason).wav, I (Jason).wav, O (Jason).wav, U (Jason).wav]
Test files: [U (Jason Test 1).wav, U (Jason Test 2).wav]

Hasil perbandingan file audio:
1. Sound between U (Jason Test 1).wav and U (Jason).wav have 20889.69821168393 distance
2. Sound between U (Jason Test 2).wav and U (Jason).wav have 22939.423973325655 distance
Jarak rata-rata untuk vokal 'U': 21514.561892504795
```

INFORMASI AKHIR
PENCARIAN DISTANCE

```
INFORMASI AKHIR:
Audio template yang dipilih yaitu: Jason (Template)
Audio test yang dipilih yaitu: Jason (Test)
Hasil perbandingan file audio untuk semua vokal: [10928.541490155822, 20582.734985343646,
15251.65943418249, 20192.76608857596, 21514.561092504795]
Jarak rata-rata untuk semua vokal: 17694.052618152542
```

PENGUJIAN PENCARIAN AKURASI

```
MENAMPILKAN INFORMASI PERBANDINGAN SUARA:

Comparing template file 'A (Jason).wav' with test files:
1. Sound between A (Jason).wav and A (Jason Test 2).wav have 6113.72178332679 distance
2. Sound between A (Jason).wav and O (Jason Test 2).wav have 8779.77847134058 distance
3. Sound between A (Jason).wav and I (Jason Test 1).wav have 10350.103322614263 distance
4. Sound between A (Jason).wav and O (Jason Test 1).wav have 12813.13428100248 distance
5. Sound between A (Jason).wav and A (Jason Test 1).wav have 15743.361196984853 distance
6. Sound between A (Jason).wav and U (Jason Test 2).wav have 16114.379574641804 distance
7. Sound between A (Jason).wav and U (Jason Test 1).wav have 17042.47792461952 distance
8. Sound between A (Jason).wav and I (Jason Test 2).wav have 17497.74191410475 distance
9. Sound between A (Jason).wav and E (Jason Test 1).wav have 17551.454648459392 distance
10. Sound between A (Jason).wav and E (Jason Test 2).wav have 17893.520803328287 distance
Shortest distance for 'A (Jason).wav' is to 'A (Jason Test 2).wav' - Correct
Jarak rata-rata untuk template 'A (Jason).wav': 13989.96739204227
```

```
Comparing template file 'E (Jason).wav' with test files:
1. Sound between E (Jason).wav and I (Jason Test 1).wav have 13420.32728319572 distance
2. Sound between E (Jason).wav and O (Jason Test 2).wav have 15887.132808275926 distance
3. Sound between E (Jason).wav and A (Jason Test 2).wav have 16611.792882907353 distance
4. Sound between E (Jason).wav and O (Jason Test 1).wav have 17229.519198421378 distance
5. Sound between E (Jason).wav and E (Jason Test 2).wav have 20345.300565873127 distance
6. Sound between E (Jason).wav and I (Jason Test 2).wav have 20818.435905829996 distance
7. Sound between E (Jason).wav and E (Jason Test 1).wav have 20820.16940481416 distance
8. Sound between E (Jason).wav and U (Jason Test 1).wav have 22419.042058876865 distance
9. Sound between E (Jason).wav and U (Jason Test 2).wav have 23565.150598795437 distance
10. Sound between E (Jason).wav and A (Jason Test 1).wav have 24391.258780202603 distance
Shortest distance for 'E (Jason).wav' is to 'I (Jason Test 1).wav' - Incorrect
Jarak rata-rata untuk template 'E (Jason).wav': 19550.812948719256
```

```
Comparing template file 'I (Jason).wav' with test files:
1. Sound between I (Jason).wav and I (Jason Test 1).wav have 9192.702612653371 distance
2. Sound between I (Jason).wav and O (Jason Test 2).wav have 11120.256506018819 distance
3. Sound between I (Jason).wav and A (Jason Test 2).wav have 12353.333430362576 distance
4. Sound between I (Jason).wav and O (Jason Test 1).wav have 15085.737798265414 distance
5. Sound between I (Jason).wav and E (Jason Test 1).wav have 18548.750594952082 distance
6. Sound between I (Jason).wav and E (Jason Test 2).wav have 18954.438110405274 distance
7. Sound between I (Jason).wav and U (Jason Test 1).wav have 19628.47415555669 distance
8. Sound between I (Jason).wav and U (Jason Test 2).wav have 20576.480462158917 distance
9. Sound between I (Jason).wav and I (Jason Test 2).wav have 21310.616255711608 distance
10. Sound between I (Jason).wav and A (Jason Test 1).wav have 22578.0300088522 distance
Shortest distance for 'I (Jason).wav' is to 'I (Jason Test 1).wav' - Correct
Jarak rata-rata untuk template 'I (Jason).wav': 16934.881993493695
```

```
Comparing template file 'O (Jason).wav' with test files:
1. Sound between O (Jason).wav and O (Jason Test 2).wav have 19525.784077269713 distance
2. Sound between O (Jason).wav and U (Jason Test 1).wav have 19687.63613007845 distance
3. Sound between O (Jason).wav and E (Jason Test 1).wav have 19950.294205562135 distance
4. Sound between O (Jason).wav and E (Jason Test 2).wav have 20367.454579677655 distance
5. Sound between O (Jason).wav and O (Jason Test 1).wav have 20859.74809988221 distance
6. Sound between O (Jason).wav and I (Jason Test 1).wav have 21420.32604355849 distance
7. Sound between O (Jason).wav and U (Jason Test 2).wav have 22667.15321509771 distance
8. Sound between O (Jason).wav and A (Jason Test 2).wav have 22937.24090451105 distance
9. Sound between O (Jason).wav and A (Jason Test 1).wav have 23528.03548563714 distance
10. Sound between O (Jason).wav and I (Jason Test 2).wav have 23963.974582283914 distance
Shortest distance for 'O (Jason).wav' is to 'O (Jason Test 2).wav' - Correct
Jarak rata-rata untuk template 'O (Jason).wav': 21490.76473235584
```

```
Comparing template file 'U (Jason).wav' with test files:
1. Sound between U (Jason).wav and O (Jason Test 2).wav have 15934.162023415405 distance
2. Sound between U (Jason).wav and I (Jason Test 1).wav have 17199.645648554473 distance
3. Sound between U (Jason).wav and A (Jason Test 2).wav have 17890.17581963096 distance
4. Sound between U (Jason).wav and O (Jason Test 1).wav have 18677.112412221173 distance
5. Sound between U (Jason).wav and U (Jason Test 1).wav have 20089.69821168393 distance
6. Sound between U (Jason).wav and U (Jason Test 2).wav have 22939.423973325655 distance
7. Sound between U (Jason).wav and E (Jason Test 2).wav have 23647.32143870706 distance
8. Sound between U (Jason).wav and I (Jason Test 2).wav have 24090.454988309684 distance
9. Sound between U (Jason).wav and E (Jason Test 1).wav have 24212.40009413332 distance
10. Sound between U (Jason).wav and A (Jason Test 1).wav have 25898.472854806678 distance
Shortest distance for 'U (Jason).wav' is to 'O (Jason Test 2).wav' - Incorrect
Jarak rata-rata untuk template 'U (Jason).wav': 21057.886746478838
```

INFORMASI AKHIR
PENCARIAN AKURASI

```
INFORMASI AKHIR:
Audio template yang dipilih yaitu: Jason (Template)
Audio test yang dipilih yaitu: Jason (Test)
Akurasi total: 60.0%
```

HASIL PENGUJIAN

PENGUJIAN TEMPLATE DEPENDENT (VOWEL SAMA)

Faris					
Audio	A	E	I	O	U
Test 1 Distance	10370.5748	7226.695664	10371.8052	5925.828905	7853.350564
Test 2 Distance	10107.57384	8443.380221	11073.12659	6392.128549	9154.012122
Average	10239.07432	7835.037943	10722.46589	6158.978727	8503.681343

Average All:	8691.847645
Percentage:	100%

Jason					
Audio	A	E	I	O	U
Test 1 Distance	15743.3612	20820.1694	9192.702613	20859.7481	20089.69821
Test 2 Distance	6113.721783	20345.30057	21310.61626	19525.78408	22939.42397
Average	10928.54149	20582.73499	15251.65943	20192.76609	21514.56109

Average All:	17694.05262
Percentage:	60%

Louis					
Audio	A	E	I	O	U
Test 1 Distance	14739.84975	8162.496651	9197.19335	6372.214293	7169.831267
Test 2 Distance	12991.75875	7337.756453	9751.771197	7003.434791	4915.732264
Average	13865.80425	7750.126552	9474.482274	6687.824542	6042.781765

Average All:	8764.203877
Percentage:	20%

Satria					
Audio	A	E	I	O	U
Test 1 Distance	12606.97749	9449.688728	14160.33705	11219.55026	9425.058353
Test 2 Distance	11504.71469	12007.05894	14410.42112	13348.13668	13211.83366
Average	12055.84609	10728.37384	14285.37908	12283.84347	11318.44601

Average All:	12134.3777
Percentage:	40%

PENGUJIAN TEMPLATE DEPENDENT (SEMUA VOWEL)

Faris

Audio	Vowel	Distance									
		A		E		I		O		U	
	A	10370.5748	10107.57384	15489.47038	15300.4888	17064.43858	19464.48163	13885.66659	14697.38889	17845.29807	18857.95737
	E	13567.21684	14681.74523	7226.69566	8443.38022	14423.24508	15565.11872	12868.11266	13024.27936	12858.32464	16188.24171
	I	16171.03433	15542.64352	9540.34595	12464.96355	10371.8052	11073.12659	11674.58481	14886.59561	14354.75444	14766.58799
	O	12116.74472	13403.08142	14590.03341	15588.86841	15689.69922	16901.81781	5925.8289	6392.12855	9056.28731	12049.95896
	U	14707.36031	15562.2247	15110.93064	15083.33976	11474.90163	14976.47982	10622.31782	10154.409	7853.35056	9154.01212

Average All:	13183.79832
Percentage:	100%

Jason

Audio	Vowel	Distance									
		A		E		I		O		U	
	A	15743.3612	6113.72178	17551.45465	17893.5208	10350.10332	17497.74191	12813.13428	8779.77847	17042.47792	16114.37957
	E	24391.25878	16611.79288	13420.32728	15887.13281	20820.1694	20818.43591	17229.5192	20345.30057	22419.04206	23565.1506
	I	22578.03001	12353.33343	18548.75059	18954.43811	9192.70261	11120.25651	15085.7378	21310.61626	19628.47416	20576.48046
	O	23528.03549	22937.2409	19950.29421	20367.45458	21420.32604	23963.97458	20859.7481	19525.78408	19687.63613	22667.15322
	U	25898.47285	17890.17582	24212.40009	23647.32144	17199.64565	24090.45499	18677.11241	15934.16202	20089.69821	22939.42397

Average All:	18604.86276
Percentage:	60%

Louis

Audio	Vowel	Distance									
		A		E		I		O		U	
	A	14739.84975	12991.75875	13627.56879	10726.8091	14753.48426	18979.11139	12170.25297	13016.35405	11566.33868	7546.03643
	E	13777.51029	14473.19322	8162.49665	7337.75645	9841.67063	12184.48632	12075.4235	11199.31086	10726.7417	7178.81785
	I	13409.47626	15374.2287	7602.51543	6866.52416	9197.19335	9751.7712	11877.57267	10581.47134	10832.38784	7204.58206
	O	11791.2339	10628.06951	10186.66061	8584.04833	11547.40689	14662.15199	6372.21429	7003.43479	7918.9828	5769.05384
	U	13380.43822	14114.99913	8151.21578	8279.72499	11089.57141	12064.52124	9456.68393	9609.95966	7169.83127	4915.73226

Average All:	10649.37259
Percentage:	20%

Average Total:	14197.3734
Percentage Total:	55%

Satria

Audio	Vowel	Distance									
		A		E		I		O		U	
	A	12606.97749	11504.71469	11032.19266	15197.91387	17813.03841	18794.42183	13763.44107	17508.57333	13278.81164	16598.68671
	E	15276.97237	15245.95927	9449.68873	12007.05894	12625.79643	12454.22967	13342.87247	18585.11364	11797.24367	17490.61595
	I	19069.81167	18373.49405	12831.41886	14541.06426	14160.33705	14410.42112	15308.15878	22591.04532	14334.18649	19727.95091
	O	13593.18103	9754.08846	10342.02363	14419.73926	17598.12334	18351.78524	11219.55026	13348.13668	12003.02037	15989.47748
	U	15533.9182	13678.90095	10142.79824	11900.76977	14380.79749	13343.84658	11624.25849	15989.47748	9425.05835	13211.83366

Average All:	14351.45993
Percentage:	40%

PENGUJIAN TEMPLATE INDEPENDENT FARIS (VOWEL SAMA)

Jason					
Audio	A	E	I	O	U
Test 1 Distance	24198.36071	18239.99812	17211.24094	19211.04127	17411.86038
Test 2 Distance	20263.65845	18510.06403	19502.44012	16477.73471	16367.54921
Average	22231.00958	18375.03107	18356.84053	16477.73471	16889.70479

Average All:	18466.06414
Percentage:	60%

Louis					
Audio	A	E	I	O	U
Test 1 Distance	35312.34476	22228.03201	28941.15206	22870.7696	22294.56295
Test 2 Distance	30768.96866	19984.21413	31750.34827	24517.70695	15613.83273
Average	33040.65671	21106.12307	30345.75017	23694.23827	18954.19784

Average All:	25428.19321
Percentage:	20%

Average Total:	22372.38927
Percentage Total:	33%

Satria					
Audio	A	E	I	O	U
Test 1 Distance	24350.6328	17913.41981	25131.04576	21600.03905	19182.98033
Test 2 Distance	25773.29692	23095.86932	23805.17809	29350.08871	22026.55374
Average	25061.96486	20504.64456	24468.11193	25475.06388	20604.76703

Average All:	23222.91045
Percentage:	20%

PENGUJIAN TEMPLATE INDEPENDENT FARIS (SEMUA VOWEL)

Jason

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	24198.36071	20263.65845	25301.20413	25278.8215	21281.95888	22371.6084	24831.49429	20413.42406	23893.0525	21916.28661
	E	23610.74921	20147.11826	18239.99812	18510.06403	16723.88061	16852.54189	19652.69458	16966.69666	20743.52929	17716.11666
	I	27390.2729	22954.2376	21791.92014	22058.23606	17211.24094	19502.44012	24058.81151	19357.78149	21871.58224	21261.12039
	O	23465.02688	18572.27323	20981.94582	21122.21853	17971.40793	18833.13831	19211.04127	16477.73471	18804.39639	18171.49458
	U	23465.02688	19995.91197	20520.44626	21122.21853	16377.42379	17398.87247	19197.54478	16080.71001	17411.86038	16367.54921

Average All:	20358.38288
Percentage:	60%

Louis

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	35312.34476	30768.96866	25103.81646	22837.44018	29041.80571	31410.21515	24236.35578	26104.25955	24534.49313	17697.91106
	E	30352.1736	27407.88668	22228.03201	19984.21413	26269.25912	28568.87857	19966.75007	21221.35304	20903.80392	14611.41284
	I	37875.25926	33578.37745	25350.83548	24142.76229	28941.15206	31750.34827	22493.50288	26242.59454	24555.59401	17252.04524
	O	32450.34103	27229.71132	24227.94228	22248.82284	28728.26754	30856.31579	22870.7696	24517.70695	24298.88109	16122.3651
	U	34526.19791	30343.57277	23245.78184	21426.2132	28312.26309	30210.19912	20733.15435	23445.1757	22294.56295	15613.83273

Average All:	25488.91846
Percentage:	20%

Satria

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	24350.6328	25773.29692	21035.98417	25337.10896	23350.12807	25279.34371	23880.0699	31055.80025	23534.57635	27354.9824
	E	20890.43773	20647.48716	17913.41981	23095.86932	24579.83062	25312.58566	20684.32373	26853.61041	19182.98033	22026.55374
	I	22905.12816	21614.3799	18400.32604	23227.55015	25131.04576	23805.17809	20956.77964	27149.0557	20810.45999	22764.27599
	O	18911.09524	21575.6746	18109.72013	22845.69089	21900.47575	24173.08198	21600.03905	26092.0511	21652.11976	22026.55374
	U	17291.29459	18078.71854	15669.67159	21127.29061	22390.45932	22728.53254	18951.89749	26092.0511	19182.98033	22026.55374

Average All:	22426.58307
Percentage:	20%

PENGUJIAN TEMPLATE INDEPENDENT JASON (VOWEL SAMA)

Faris					
Audio	A	E	I	O	U
Test 1 Distance	12081.10911	19160.9476	17362.09244	21945.2903	16882.4999
Test 2 Distance	15769.53859	18175.28331	19409.79589	22699.54908	16111.36712
Average	13925.32385	18668.11546	18385.94417	22322.41969	16496.93351

Average All:	17959.74733
Percentage:	40%

Louis					
Audio	A	E	I	O	U
Test 1 Distance	31077.38052	24672.06941	26854.50733	24936.79633	25998.18052
Test 2 Distance	27005.78776	22508.37837	28267.7555	24372.41649	24689.71561
Average	29041.58414	23590.22389	27561.13142	24654.60641	25343.94807

Average All:	26038.29879
Percentage:	20%

Average Total:	21668.0536
Percentage Total:	27%

Satria					
Audio	A	E	I	O	U
Test 1 Distance	19267.43254	15777.93816	18451.23292	25483.02733	18167.95716
Test 2 Distance	20591.55851	20053.73716	20797.01932	31007.1761	20464.06754
Average	19929.49552	17915.83766	19624.12612	28245.10171	19316.01235

Average All:	21006.11467
Percentage:	20%

PENGUJIAN TEMPLATE INDEPENDENT JASON (SEMUA VOWEL)

Faris

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	12081.11	15769.54	15278.4	17944.63	16338.73	21034.53	13333.51	14677.69	15415.93	19111.56
	E	20314.31	21970.25	19160.95	18175.28	16734.68	18184.98	19033.95	19770.5	17670.66	19525.01
	I	18021.23	19882.94	19669.22	19901.05	17362.09	19409.8	18223.69	19373.34	16061.66	20832.58
	O	25608.7	26447.05	26307.76	24320.71	24691.35	25017.63	21945.29	22699.55	19959.82	22597.98
	U	22403.24	23287.4	23465.25	22223.26	19501.65	20150.64	18891.47	20262.78	16882.5	16111.37

Average All:	19660.784
Percentage:	40%

Louis

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	31077.38	27005.79	22318.56	19010.51	25487.24	27984.2	21242.02	21888.94	22419.26	15296.14
	E	30673.65	28469.87	24672.07	22508.38	25821.32	29150.25	23181.64	23101.35	23382.15	21788.06
	I	29240.82	27237.61	22851.35	21748.5	26854.51	28267.76	22407.26	22439.65	21907.84	20255.6
	O	31018.25	27417.66	26061.3	25484.33	29228.52	31245.49	24936.8	24372.42	24782.7	23184.08
	U	33055	30388.45	27448.8	26345.15	28567.72	31633.12	25785.36	26098.55	25998.18	24689.72

Average All:	25548.6256
Percentage:	20%

Satria

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	19267.43	20591.56	14648.08	18851.12	16677.85	21422.41	19164.41	27963.45	19781.25	23696.47
	E	20998.39	19403.58	15777.94	20053.74	21682.73	22087.75	18836.88	25638.13	18340.45	18994.79
	I	20440.74	18882.9	14872.21	18575.8	18451.23	20797.02	18025.7	25419.16	17253.18	20254.69
	O	27112.77	25363	23973.67	27640.69	29203.7	30076.8	25483.03	31007.18	24771.98	25714.57
	U	20249.87	18193.64	16982.66	20103.5	22725.86	22858.58	19310.21	25710.29	18167.96	20464.07

Average All:	21439.3014
Percentage:	20%

PENGUJIAN TEMPLATE INDEPENDENT LOUIS (VOWEL SAMA)

Faris					
Audio	A	E	I	O	U
Test 1 Distance	13449.01914	15855.34095	15390.24796	14708.23353	12889.24074
Test 2 Distance	16680.77403	17679.05354	20674.10409	13725.27124	17613.95541
Average	15064.89659	16767.19725	18032.17602	14216.75238	15251.59807

Average All:	15866.52406
Percentage:	0%

Jason					
Audio	A	E	I	O	U
Test 1 Distance	21825.23724	21295.31891	15957.61118	19804.75696	18926.38436
Test 2 Distance	16257.65349	21544.67874	17910.95998	14719.06826	17309.75437
Average	19041.44537	21419.99882	16934.28558	17261.91261	18118.06936

Average All:	18555.14235
Percentage:	20%

Average Total:	17407.84111
Percentage Total:	13%

Satria					
Audio	A	E	I	O	U
Test 1 Distance	18964.25504	14541.49445	15848.67849	15302.30934	15145.89127
Test 2 Distance	19372.08246	19806.15474	16403.7174	23957.90315	18676.08296
Average	19168.16875	17173.82459	16126.19795	19630.10624	16910.98711

Average All:	17801.85693
Percentage:	20%

PENGUJIAN TEMPLATE INDEPENDENT LOUIS (SEMUA VOWEL)

Faris

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	13449.01914	16680.77403	14084.12066	16965.27985	13816.24811	19892.01888	14097.01884	12513.13321	11981.8047	16992.98647
	E	12904.81795	16569.64851	15855.34095	17679.05354	16143.72981	21493.4973	15879.81681	15196.33148	14975.95108	19614.08397
	I	12679.80929	16023.71398	15750.27544	17524.88303	15390.24796	20674.10409	15403.2435	14335.06325	14717.61394	18887.11024
	O	13253.61377	16320.82807	13427.32884	15559.37498	12687.18641	18765.11447	14708.23353	13725.27124	11884.50202	16947.18768
	U	12137.14676	15332.22421	13685.30813	15895.55731	13480.04579	18851.14085	13912.1371	13127.0379	12889.24074	17613.95541

Average All:	15447.4635
Percentage:	0%

Jason

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	21825.23724	16257.65349	19752.59983	21191.32332	15658.79803	18004.40934	19160.80609	15028.82302	20039.55659	18816.89611
	E	21937.65714	16789.86262	21295.31891	21544.67874	16818.89765	18634.05865	22129.06908	16278.01265	21117.09726	19584.5618
	I	21486.49142	16015.05126	20824.99679	21122.67864	15957.61118	17910.95998	21477.28038	15695.81281	20480.45811	18970.05047
	O	20878.37695	16118.11223	19143.46405	19876.50511	15350.67394	17049.60299	19804.75696	14719.06826	19796.7037	18280.31801
	U	20185.08261	15075.8897	19177.14191	19688.92102	14984.50049	16527.00868	20006.66963	14342.37735	18926.38436	17309.75437

Average All:	18580.96042
Percentage:	20%

Satria

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	18964.25504	19372.08246	14447.21616	20378.22382	18744.15652	20975.01644	16405.25152	26157.95887	17935.54258	20396.80979
	E	22280.76306	22709.41833	14541.49445	19806.15474	16763.00897	18056.51412	16471.14118	28038.05872	19561.69342	24424.03246
	I	21625.10714	22324.78838	14312.92672	19576.19675	15848.67849	16403.7174	16447.34621	28346.70189	18383.63158	21600.42878
	O	19099.38112	16865.62351	13689.61215	20171.82048	18026.23701	20756.97361	15302.30934	23957.90315	17880.72173	20139.90859
	U	19517.58552	18328.21606	13181.57346	17145.18518	15936.21484	18176.3663	13612.71978	22671.25751	15145.89127	18676.08296

Average All:	18991.59799
Percentage:	20%

PENGUJIAN TEMPLATE INDEPENDENT SATRIA (VOWEL SAMA)

Faris					
Audio	A	E	I	O	U
Test 1 Distance	14629.56873	19481.55115	18548.45628	16941.80339	15764.76707
Test 2 Distance	16490.92938	19317.64682	21267.22189	16590.05549	16569.20567
Average	15560.24905	19399.59898	19907.83909	16765.92944	16166.98637

Average All:	17560.12059
Percentage:	20%

Jason					
Audio	A	E	I	O	U
Test 1 Distance	22598.65752	22636.70151	15845.49133	16802.995	19279.31749
Test 2 Distance	12864.98326	23134.16061	20712.75714	13479.11773	18263.84939
Average	17731.82039	22885.43106	18279.12424	15141.05637	18771.58344

Average All:	18561.8031
Percentage:	20%

Average Total:	18725.81089
Percentage Total:	20%

Louis					
Audio	A	E	I	O	U
Test 1 Distance	26564.95448	19802.31552	20511.85637	17548.55222	18939.7676
Test 2 Distance	22357.72145	18905.5852	21224.59195	20775.26828	13924.47694
Average	24461.33797	19353.95036	20868.22416	19161.91025	16432.12227

Average All:	20055.509
Percentage:	20%

PENGUJIAN TEMPLATE INDEPENDENT SATRIA (SEMUA VOWEL)

Faris

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	14629.56873	16490.92938	13560.49574	15036.46487	13821.18784	17190.84705	14342.23471	14870.45924	12896.844	14691.26656
	E	15831.22801	16823.37955	19481.55115	19317.64682	17594.10774	19653.31894	16567.85062	16253.32385	16092.04677	16686.85097
	I	16010.31344	17839.91842	19635.21459	20384.04275	18548.45628	21267.22189	18560.13629	18251.90142	18180.59553	19871.53907
	O	17446.28368	18228.15795	16631.25971	16623.52876	14200.91503	17551.77947	16941.80339	16590.05549	14208.42874	15480.95399
	U	16359.23296	17437.51439	17722.35348	17852.87222	15832.69158	18044.9216	16981.72376	16342.05188	15764.76707	16569.20567

Average All:	16863.82886
Percentage:	20%

Jason

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	22598.65752	12864.98326	17179.97547	18422.29953	12687.69493	17502.27455	14051.57355	10480.71865	17834.46993	17529.85213
	E	23376.5975	13762.77664	22636.70151	23134.16061	14784.6334	18778.49138	18342.40294	14302.95072	19236.80949	19180.66948
	I	25688.15433	14369.91622	23597.32494	24093.05467	15845.49133	20712.75714	20005.99899	15550.1938	22478.90859	21433.60978
	O	25257.04906	15434.86971	20142.46112	21040.47733	13557.31561	17797.58629	16802.995	13479.11773	19055.39513	18696.47879
	U	23185.07239	13678.81103	21520.26159	21290.22137	12402.74665	17941.51201	17011.0893	12580.61886	19279.31749	18263.84939

Average All:	18217.62698
Percentage:	20%

Louis

Audio	Vowel	Distance									
		A		E		I		O		U	
		Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2	Test Case 1	Test Case 2
	A	26564.95	26848.34	20985.79	18717.21	24105.06	24105.06	16428.33	18819.16	18732.74	12995.16
	E	30580.14	28707.34	18905.59	19802.31	21707.76	25232.69	21003.45	23075.37	15011.06	18311.41
	I	28618.64	27949.59	17177.49	17580.18	20511.86	21224.59	19746.74	22099.18	20384.45	14514.54
	O	30812.28	26035.75	20169.2	20791.19	25895.06	27159.46	17548.55	20775.27	19417.4	14410.64
	U	27550.48	26301.65	18814.37	20850.55	18760.88	18939.77	18311.41	20850.55	13924.48	13924.48

Average All:	21233.792
Percentage:	20%

TOTAL RATA-RATA (VOWEL SAMA)

Nama	Kategori	DEPENDENT	INDEPENDENT
Faris	Average Distance	8691.847645	22372.38927
	Average Percentage	100%	33%
Jason	Average Distance	17694.05262	21668.0536
	Average Percentage	60%	27%
Louis	Average Distance	8764.203877	17407.84111
	Average Percentage	20%	13%
Satria	Average Distance	12134.3777	18725.81089
	Average Percentage	40%	20%

TOTAL RATA-RATA (SEMUA VOWEL)

Nama	Kategori	DEPENDENT	INDEPENDENT
Faris	Average Distance	13183.79832	22757.96147
	Average Percentage	100%	33%
Jason	Average Distance	18604.86276	17673.34064
	Average Percentage	60%	13%
Louis	Average Distance	10649.37259	16863.82886
	Average Percentage	20%	20%
Satria	Average Distance	14351.45993	22216.237
	Average Percentage	40%	27%

ANALISIS HASIL UJI

Untuk hasil dependen:

- Hasil pengujian beragam, mulai dari akurasi yang kecil untuk data test Louis dengan akurasi 20% hingga akurasi yang tinggi untuk data test Faris

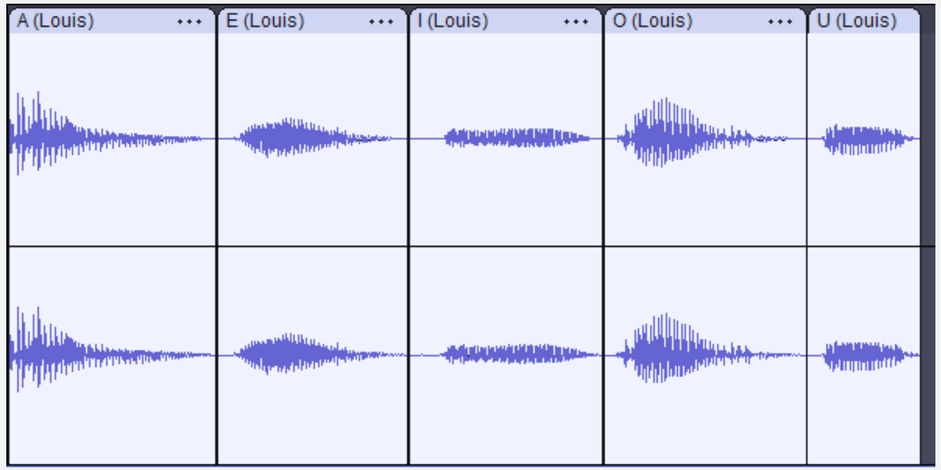
Untuk hasil independen:

- Akurasi yang didapat beragam, namun tergolong kecil dengan nilai akurasi tertinggi adalah 60% untuk pengetesan data template Faris terhadap data uji Jason

General:

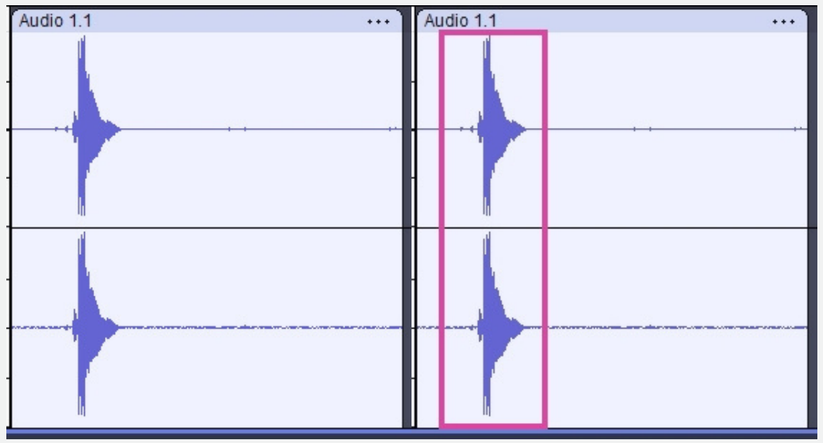
- Untuk kesalahan klasifikasi vowel cenderung terjadi pada data vowel “E” dan “U”

ANALISIS HASIL UJI



- Bedasarkan gambar di samping, bisa dilihat bahwa gelombang untuk setiap vowels hampir mirip namun terdapat variasi yang membedakannya
- Perbedaan pengucapan juga akan berpengaruh pada hasil yang didapat, sehingga sering kali didapat distance terkecil malah untuk vowel yang berbeda dengan aslinya

KESIMPULAN



- Berdasarkan gambar disamping, dapat diamati bahwa durasi dari template audio yang diujikan cukup panjang sehingga dapat dioptimasi dengan hanya mengambil bagian bergelombang (tidak hening).
- Jarak hasil pengujian terhadap orang sama lebih pendek dibandingkan dengan pengujian terhadap orang berbeda.
- Penggunaan device dalam perekaman audio mempengaruhi jarak.

REFERENSI

- https://python-speech-features.readthedocs.io/en/latest/
- https://www.geeksforgeeks.org/dynamic-time-warping-dtw-in-time-series/
- https://www.youtube.com/watch?v=X6phfLqN5pY

LAMPIRAN

- **LINK GITHUB**
  https://github.com/jasonrivalino/IF4071_DTW.git

- **LINK SPREADSHEET HASIL PENGUJIAN**
  https://docs.google.com/spreadsheets/d/1MiiCBvYBRKWpxiEW73g4gpe85_wZs6FGIKIDpAVIFw8/edit?usp=sharing

THANK YOU