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Analysis of digital voice features extraction methods

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Abstract
K means method and LBP based methods are commonly used for manipulating digital wave files, and they can be used for wave file features extraction, these features can be used later on as a wave file key or signature which refers to the wave file in any application, such as voice recognition or voice retrieval applications.
K means method can be used to extract voice features, these features can be represented by clusters points, or within_cluster sums, or by the clusters centroids, and in this paper we will investigate the both methods in order to do some recommendations regarding the efficient method of voice features extraction.

Keywords: wave file, k means, LBP, RLBP, histogram, features, speedup

1. Introduction

Digital signals such as digital color images [1, 2], and audio signals [3] usually have a huge sizes, which makes it difficult to use a digital file for retrieving or recognition purposes.
Digital wave file is considered as one of the mostly used file type in a present. This type of digital files is used in several applications, such as human knowledge and many security and banking applications. A digital voice is a sinusoidal signal and usually has a large size where the acoustic signal consists of a set of values distributed in one column (mono wave file signal) or distributed in two columns (stereo wave file signal), these values usually are the range -1 to 1 and they are formed as a results of sampling and quantization of the original analogue voice signal [1, 2] as shown in figures 1 and 2.

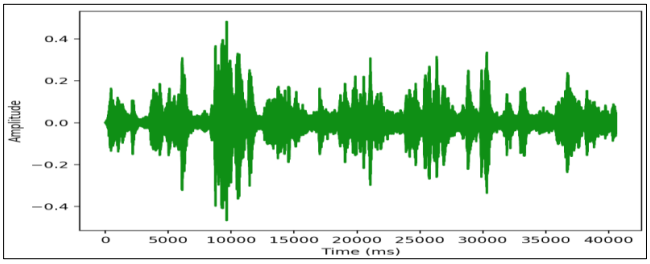

Fig 1: Wave file example

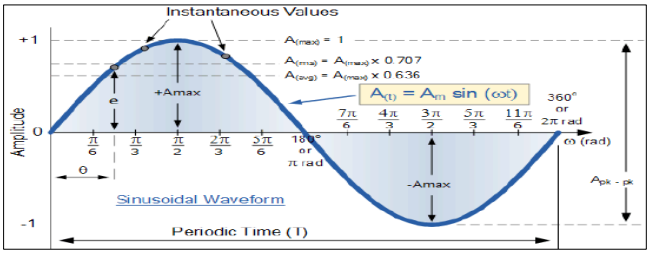

Fig 2: Wave file as a Sinusoidal signal

Since the size of the wave file is very large [3, 4, 17], it is difficult to conduct the matching of two wave files using all the amplitude values, here the matching process will require a big amount of time, which in turn leads to delay in the process of voice recognition [5, 7]. Table 1 shows the results of voice matching with itself, and here we can see that the bigger wave file size will increase the matching time, and the process of matching requires a big amount of time [21, 40].

Table 1: Matching time for different wave files

Wave file	File size (elements)	Number of values	Matching time (seconds)
W1	36787x2	73574	0.006000
W2	39730x2	79460	0.008000
W3	33844x2	67688	0.007600
W4	17658x2	35316	0.005000
W5	41202x2	82404	0.007900
W6	36787x2	73574	0.006000
W7	63274x2	126548	0.014000
W8	48049x2	96098	0.010000
W9	55916x2	111832	0.013000
W10	89760x2	179520	0.019000
	Average	92601	
	Cost of 1 value	9700/92601.1048 microseconds	

To minimize the matching (recognition) time [10], we have to use a method to create a wave file features, by generating a set of unique values (features) for any wave file, this set can be used as a primary key or a signature to retrieve or recognize the wave file. Any normalized wave file can be represented by a sinusoidal signal as shown in Figure 2. [1, 3], this signal can characterize by the following parameters: amplitude, frequency and phase shifting. If the features are based on these parameters, to any changes on these parameters must not affect the extracted voice features [11, 12].

Different methods are now used to extract wave file features, many of these methods are based on calculating local binary pattern (LBP), and these patterns can be used to form a features array similar to signal histogram [13]. Many methods were proposed based on LBP [14, 17], such as central symmetric LBP (CSLBP) and reduced LBP (RLBP), these methods were introduced to reduce the number of elements in the features array [15, 16]. Figure 3 shows how to calculate LBP operator for each value:

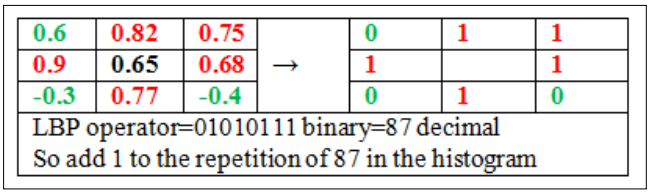

Fig 3: LBP calculation

Using calculated LBP operators (histogram) we can reduce the matching (recognition) time as shown in table 2:

Table 2: Matching times using LBP operators

Image	Number of elements (pixels) in wave file	Number of elements in histogram data set	Matching time(s) using wave file	Matching time(s) using histogram	Speedup of using histogram
1	77976	256	0.011000	0.0000200	550
2	141000	256	0.019000	0.0000200	950
3	150849	256	0.020000	0.0000200	1000
4	151353	256	0.021000	0.0000200	1050
5	518400	256	0.072000	0.0000200	3600
6	3817152	256	0.527000	0.0000200	26350
7	4326210	256	0.610000	0.0000200	30500
8	5140800	256	0.715000	0.0000200	35750

2. Reduced LBP method of features extraction

This method is based on LBP method of feature extraction and it can be implemented applying the following steps:

- Get the digital wave file.
- Reshape the wave file into one row of amplitude values.
- For each value in the row apply the following:

1. Get the average of the four values left to the value (a0).
2. Get the average of the four values right to the value (a1).
3. Apply the calculations shown in figure 4:

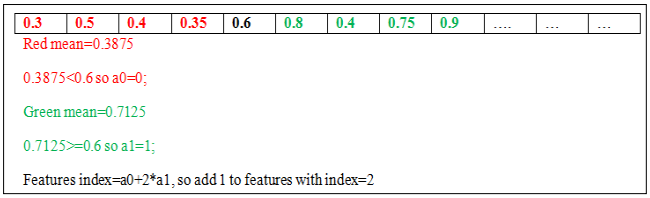

Fig 4: RLBP calculations

Based on this method we can create a unique features array for each file, each of them consists of 4 elements. This method was implemented using various wave files with different sizes; table 3 shows the results of implementation. From these results we can see that each wave file features array is a unique, and it can be used as a signature to recognize the wave file.

Table 3: Wave files features obtained by RLBP method

Wave file	Extraction time(S)	LBP features			
Cow	1.228000	18479	12142	12385	18913
Cow2	0.688000	9952	7860	7724	9443
Dog	1.842000	34874	8931	8911	39413
Dolphin	1.573000	27369	14201	14175	22834
Donkey	4.729000	85841	31491	31453	89194
Duck	8.010000	101809	101494	101396	106364
Elephant	0.945000	11879	10774	10741	11631
Horse	0.642000	7526	7339	7554	8666
Hello	1.784000	28450	16585	16789	23671
Spock	3.508000	67919	34950	34920	37770

3. Wave file clustering using k-mean method

Clustering means grouping data items into clusters as shown in figure 5

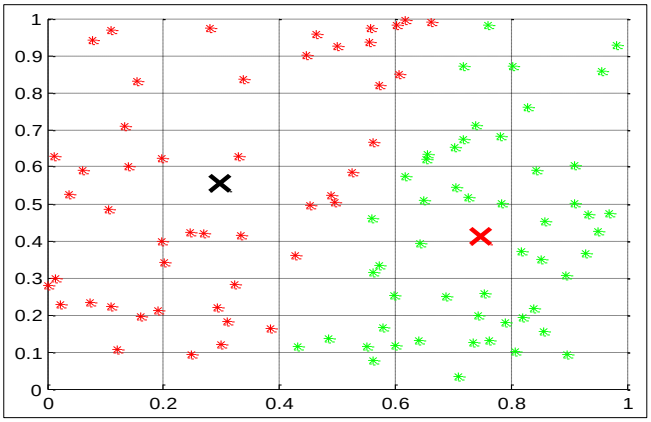

Fig 5: Data items clustering

Applying clustering we can represent the input data set by a set of feature, which can be formed by one or more of the following calculated parametors:

- The clusters centroids.
- The number of points (data items) belong to each cluster.
- The within cluster sums (WCS).

One of the most efficient methods of clustering is K means clustering methods and it works [18, 19, 20] using the following steps:

1. Initialization:
- Get the wave file.
- Normalize the wave file by reshaping it into one row, and getting the integer part of multiplication the absolute value of the amplitude by 256.
- Calculate the histogram of the normalized file.
- Select the number of clusters, and the centroid of each cluster.

2. While there are changes in the calculated centroids perform the following pass:

a. Calculate the distances between each point and cluster centroid, which is equal to absolute value of the deference between the center and the data item value.

b. According to distance, select the cluster which the points are belong to.
c. Find the new center by averaging the points within the cluster.

The following example illustrates how this method works (see tables 4-9):

- Initialization

Number of clusters =2
Centroids c1=50; c2=100;

Table 4: Pass1

x	Distant 1 Abs(x-c1)	Distant 2 Abs(x-c2)	Nearest Cluster	New centers Pass 1
242	192	142	2	C1=35.3333 C2=180.1765
58	8	42	1	
154	104	54	2	
123	73	23	2	
227	177	127	2	
194	144	94	2	
116	66	16	2	
4	46	96	1	
209	159	109	2	
113	63	13	2	
156	106	56	2	
201	151	101	2	
235	185	135	2	
188	138	88	2	
44	6	56	1	
103	53	3	2	
238	188	138	2	
233	183	133	2	
104	54	4	2	
227	177	127	2	

Table 5: Pass 2

x	Distant 1	Distant 2	Nearest cluster	New centers Pass 2
242	206.6667	61.8235	2	C1=54 C2=170.0556
58	22.6667	122.1765	2	
154	118.6667	26.1765	2	
123	87.6667	57.1765	2	
227	191.6667	46.8235	2	
194	158.6667	13.8235	2	
116	80.6667	64.1765	2	
4	31.3333	176.1765	1	
209	173.6667	28.8235	2	
113	77.6667	67.1765	2	
156	120.6667	24.1765	2	
201	165.6667	20.8235	2	
235	199.6667	54.8235	2	
188	152.6667	7.8235	2	
44	8.6667	136.1765	2	
103	67.6667	77.1765	2	
238	202.6667	57.8235	2	
233	197.6667	52.8235	2	
104	68.6667	76.1765	1	
227	191.6667	46.8235	2	

Table 6: Pass3

x	Distant 1	Distant 2	Nearest cluster	New centers Pass 3
242	188	71.9444	2	C1=62.6000 C2=183.3333
58	4	112.0556	1	
154	100	16.0556	2	
123	69	47.0556	2	
227	173	56.9444	2	
194	140	23.9444	2	
116	62	54.0556	2	
4	50	166.0556	1	
209	155	38.9444	2	
113	59	57.0556	2	
156	102	14.0556	2	
201	147	30.9444	2	
235	181	64.9444	2	
188	134	17.9444	2	
44	10	126.0556	1	
103	49	67.0556	1	
238	184	67.9444	2	
233	179	62.9444	2	
104	50	66.0556	1	
227	173	56.9444	2	

Table 7: Pass4

x	Distant 1	Distant 2	Nearest cluster	New centers Pass 4
242	179.4000	58.6667	2	C1=77.4286 C2=193.9231
58	4.6000	125.3333	1	
154	91.4000	29.3333	2	
123	60.4000	60.3333	2	
227	164.4000	43.6667	2	
194	131.4000	10.6667	2	
116	53.4000	67.3333	1	
4	58.6000	179.3333	1	
209	146.4000	25.6667	2	
113	50.4000	70.3333	1	
156	93.4000	27.3333	2	
201	138.4000	17.6667	2	
235	172.4000	51.6667	2	
188	125.4000	4.6667	2	
44	18.6000	139.3333	1	
103	40.4000	80.3333	1	
238	175.4000	54.6667	2	
233	170.4000	49.6667	2	
104	41.4000	79.3333	1	
227	164.4000	43.6667	2	

Table 8: Pass 5

x	Distant 1	Distant 2	Nearest cluster	New centers Pass 5
242	164.5714	48.0769	2	C1=83.1250 C2=199.8333
58	19.4286	135.9231	1	
154	76.5714	39.9231	2	
123	45.5714	70.9231	1	
227	149.5714	33.0769	2	
194	116.5714	0.0769	2	
116	38.5714	77.9231	1	
4	73.4286	189.9231	1	
209	131.5714	15.0769	2	
113	35.5714	80.9231	1	
156	78.5714	37.9231	2	
201	123.5714	7.0769	2	
235	157.5714	41.0769	2	
188	110.5714	5.9231	2	

44	33.4286	149.9231	1	
103	25.5714	90.9231	1	
238	160.5714	44.0769	2	
233	155.5714	39.0769	2	
104	26.5714	89.9231	1	
227	149.5714	33.0769	2	

Table 9: Pass6

x	Distant 1	Distant 2	Nearest cluster	New centers Pass 6
242	158.8750	42.1667	2	C1=83.1250 C2=199.8333 No change Cluster1 :58,123,116,4,113,4,103, 104 Cluster 2: 242, 154, 227, 194,209, 156,201, 235, 188, 238, 233,227
58	25.1250	141.8333	1	
154	70.8750	45.8333	2	
123	39.8750	76.8333	1	
227	143.8750	27.1667	2	
194	110.8750	5.8333	2	
116	32.8750	83.8333	1	
4	79.1250	195.8333	1	
209	125.8750	9.1667	2	
113	29.8750	86.8333	1	
156	72.8750	43.8333	2	
201	117.8750	1.1667	2	
235	151.8750	35.1667	2	
188	104.8750	11.8333	2	
44	39.1250	155.8333	1	
103	19.8750	96.8333	1	
238	154.8750	38.1667	2	
233	149.8750	33.1667	2	
104	20.8750	95.8333	1	
227	143.8750	27.1667	2	

A matlab codes were written to implement k mean method of clustering. Deferent wave files were taken as an input data set; table 10 shows the results of implementation:

Table 10: K mean clustering features

Wave file	Extraction time (S)	Clusters centers (features)			
Cow	0.699000	211	141	83	24
Cow2	0.417000	175	108	58	16
Dog	0.943000	255	255	58	6
Dolphin	0.839000	255	255	255	9
Donkey	2.457000	255	255	255	16
Duck	4.129000	255	255	35	3
Elephant	0.507000	255	255	255	12
Horse	0.396000	232	148	76	22
Hello	0.608000	170	106	48	4
Spock	1.184000	194	111	56	15

We can see from tables 10 and 3 that the obtained features by both methods are unique, and each of them can be used as a key to retrieve or recognize the wave file, K mean method has an advantage, this method reduces the time required to calculate the wave file features and it has a significant big speedup comparing with RLBP method as shown in table 11.

Table 11: Speedup calculation

K mean clustering extraction time (S)	RLBP extraction time(S)	Speedup of K mean clustering
0.699000	1.228000	1.7568
0.417000	0.688000	1.6499
0.943000	1.842000	1.9533
0.839000	1.573000	1.8749
2.457000	4.729000	1.9247
4.129000	8.010000	1.9399
0.507000	0.945000	1.8639
0.396000	0.642000	1.6212
0.608000	1.784000	2.9342
1.184000	3.508000	2.9628
Average		2.0482

Conclusion

Two methods of wave file features extraction were implemented and from the obtained results we can conclude the following facts:

- Methods, k mean clustering and RLBP suit the process of digital wave file features extraction.
- The number of clusters can be varying, so the length of the features set will be varying.
- The features set can be formed from the clusters centers, or/and from the number of points in each cluster, or/and from

The within cluster sums.

- For each wave file the extracted features set is a unique and it cab used as a signature or a key to identify or recognize the image.
- K_mean method is more efficient, and it has a smaller time of features extraction.

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