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Wave File Features Extraction using Reduced LBP

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ABSTRACT

In this work, we present a novel approach for extracting features of a digital wave file. This approach will be presented, implemented and tested. A signature or a key to any wave file will be created. This signature will be reduced to minimize the efforts of digital signal processing applications. Hence, the features array can be used as key to recover a wave file from a database consisting of several wave files using reduced Local binary patterns (RLBP). Experimental results are presented and show that The proposed RLBP method is at least 3 times faster than CSLBP method, which mean that the proposed method is more efficient.

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1. INTRODUCTION

The Digital wave file (DWF) represents the sampled and quantized sound wave which happens to be above or below the equilibrium or ambient air pressure [1], [2]. The sampled values are organized in one column (for mono DWF) or in two columns (for stereo DWF), so we can deal with DWF as a matrix which consists of positive and negative values over the its entire range of samples [3], [4], [5]. Figure 1 shows some samples of a DWF, while the Figure 2 shows the wave of a DWF.

-0.0156	-0.0156
-0.0156	-0.0156
-0.0156	-0.0156
-0.0078	-0.0078
-0.0078	-0.0078
0	0
-0.0078	-0.0078
-0.0078	-0.0078
-0.0078	-0.0078
-0.0078	-0.0078

Figure 1. Samples of DWF

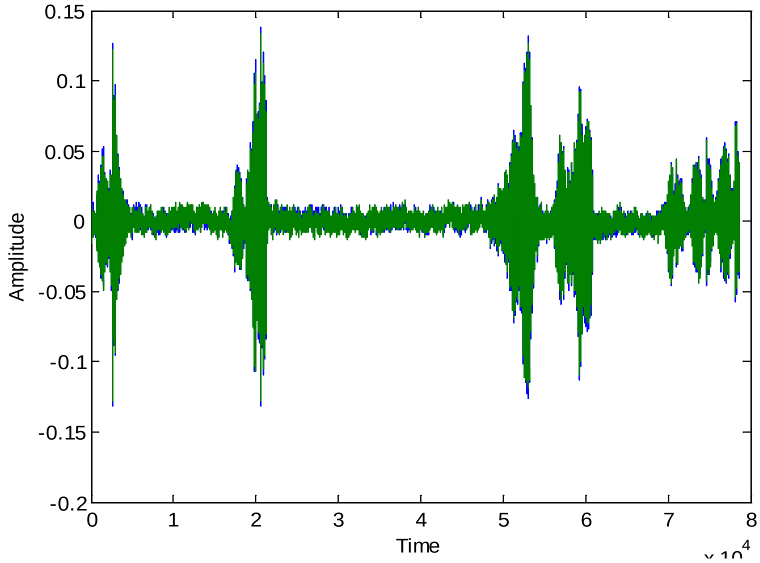

Figure 2. Samples of DWF

One of the most used applications involved with DWF processing is voice recognition. Hence, most of these applications use the nature of DWF to extract voice feature by mean of calculating several parameters like zero-crossing, dynamic range and peak value [6], [7], [15]. Calculating these parameters require understanding the voice nature, and some time they do not give an acceptable recognition ratio if we use them to recognize the voice [6], [7], [8].

To avoid the above mentioned weakness, we propose a method which can deal with DWF using two dimensional matrix. This can be done by converting the one or two column voice array to two dimensional matrix with multiple rows and columns. Hence, the DWF can be represented as a gray image, as shown in Figure 3.

-0.0078	-0.0313	0.1094
0.0078	0.0469	-0.0469
-0.2031	0.0234	-0.0625

Figure 3. Part of DWF represented by matrix

In this paper, once the DWF is converted to a matrix, then the features of DWF can be obtained using the neighborhood concepts, by considering the point in the center and the point neighbors as shown in Figure 4. This technique is called local binary pattern (LBP) [9]. LBP computes binary numbers by labeling the pixels of an image through thresholding the 3x3-neighborhood of each pixel with the center value. The procedures of calculating these patterns are shown in Figures 5 and Figure 6 [10], [11],[14]. Figure 7 shows an example of calculating LBP for a matrix.

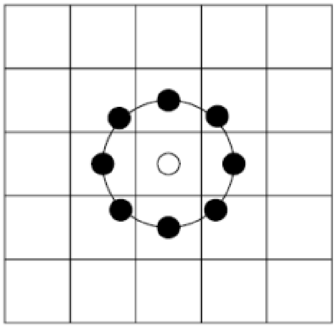

Figure 4. Point neighborhood

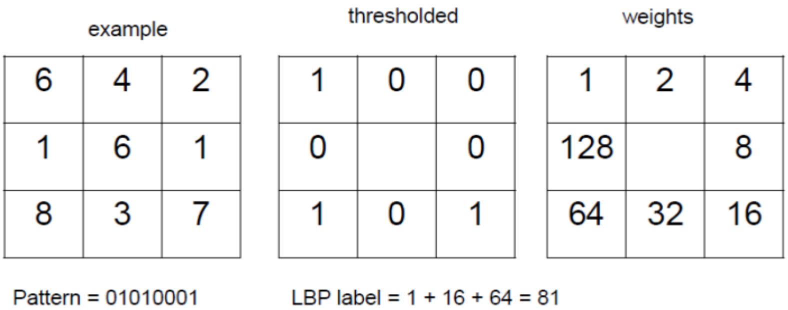

Figure 5. Generating binary pattern

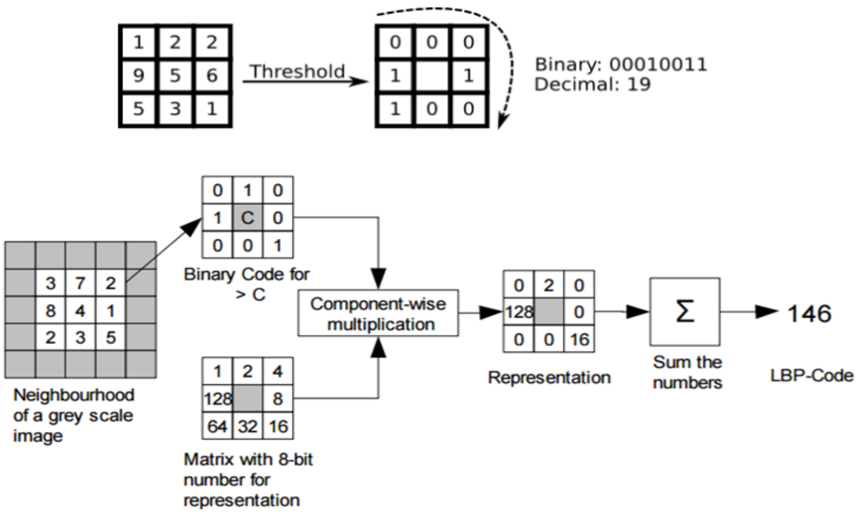

Figure 6. LBP calculation procedures

```
Original_matrix =

    15    20    30    40    15
    20   100   105    30    40
    50    30   105    50    50
   100    10   100   150   100
    15    20    20    20    20


LBP_matrix =

     0     0     0     0
     0    24    32   251
     0   222    18   249
     0   255    10     0
```

Figure 7. LBP calculation example

Using the LBP method to create features for signal recognition leads to extra efforts because the size of the generated features array is very big and it contains 256 entries (repetitions for the values from 0 to 255) [10]. To minimize the number of entries in the features array we can use center symmetric LBP (CSLBP) which can generate a features array with 16 entries [11], [12],[13]. The procedure of calculating CSLBP is shown in Figure 8, while the Figure 9 shows an example of calculating CSLBP. It can be shown from Figure 9 that the CSLBP reduces the feature array entries to 16. Hence, the CSLBP minimize the requirements needed to apply voice recognition process.

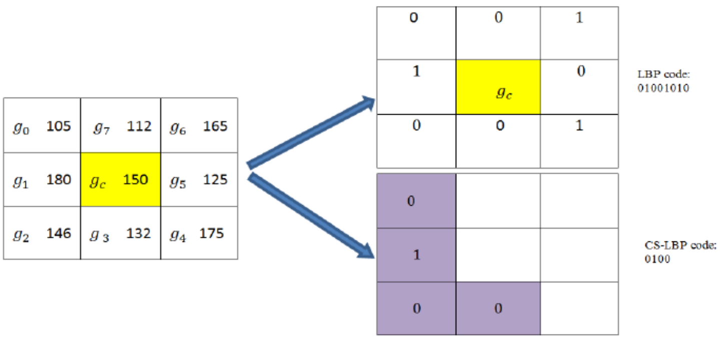

Figure 8. Procedures to calculate CSLBP

```
Original_matrix =

    15    20    30    40    15
    20   100   105    30    40
    50    30   105    50    50
   100    10   100   150   100
    15    20    20    20    20
```

```
features =

     2
     1
     0
     2
     0
     0
     1
     0
     0
     0
     0
     0
     1
     0
     1
     1
```

Figure 9. CSLBP calculation example

2. PROPOSED METHOD

The proposed method is based on CSLBP to create a DWF features array. The main contribution of the proposed method lay in reducing the number of entries from 16 to 4 entries. The obtained DWF features array by proposed method can be used for various applications such as:

a. Identifying the voice, because the feature array is a unique array for each DWF.
b. Using features array as a key to retrieve a wave file from a database consisting of several wave files.
c. Using features array as an input data set to any recognition or expert system.
d. Finding whether the DWF is disrupted or not, knowing the accurate features array of original DWF.

The proposed method using reduced LBP can be implemented by applying the following steps:

a. Get DWF.
b. Get the size of the DWF array (r: row, c: columns which is always 1 for mono files or 2 for stereo one).
c. Reshape the matrix of DWF to one column array(R).
d. Get M as a multiplication of r and c.
e. Find S as a floor of the square root of M.
f. Square S to get SS.
g. Get a number of values of R equal to SS and store them in RR array.
h. Reshape RR array to a square matrix (MR) (with rows=S, and columns=S).
i. Initialize features array to zero (FA=zeros (4, 1)).
j. For each point in MR calculate the reduced LBP applying the following steps as shown in Figure 10:
   1) Find a threshold value using the following formula:

      T=(I(i,j+1) + I(i+1, j)+I(i,j-1)+I(i-1,j)+I(i+1,j+1)+I(i+1,j-1)+ I(i-1, j-1)+I(i-1,j+1)-8*I(i,j))/9;

   2) Find the following two binary digits

      A0=((I(i,j+1) + I(i+1, j)-I(i,j-1)-I(i-1,j) > T));
      B0=((I(i+1,j+1)+I(i+1,j-1) - I(i-1, j-1)-I(i-1,j+1) > T));

   3) Get the index of FA as:

      IFA=A0*2^0+B0*2^1

   4) Increment FA(IFA=1) by 1

k. Save FA.
   The following Matlab code was written to implement the proposed method:
   [aa fs]=wavread('C:\Users\win 7\Desktop\voice\horse.wav');

```
[n1 n2]=size(aa); a1=reshape(aa,n1*n2,1); b=n1*n2;
b1=floor(sqrt(b)); a2(:,1)=a1(1:b1*b1,1);
I=reshape(a2,b1,b1);
size(I)
 h=zeros(4,1);
[y x]=size(I);
for i=2:y-1
 for j=2:x-1
 T=(I(i,j+1)+I(i+1,j)+I(i,j-1)+I(i-1,j)+I(i+1,j+1)+I(i+1,j-1)+I(i-1, j-1)+I(i-1,j+1)-8*I(i,j))/9;
 % keeping I(j,i) as center we compute CSLBP
 a=((I(i,j+1) + I(i+1, j)-I(i,j-1)-I(i-1,j) > T ) * 2^0 );
 b=((I(i+1,j+1)+I(i+1,j-1) - I(i-1, j-1)-I(i-1,j+1) > T ) * 2^1 );
 e=a+b;
 h(e+1)=h(e+1) + 1;
 end
end
h
```

One of the sample DWF used in the implementation process size=15547 * 2
then
fix (sqrt (15547 * 2))=176
Voice matrix size=176*176

3. RESULTS AND ANALYSIS

In this section, The propped method was implemented several times using various DWF with different sizes, Table 1 shows some implementation samples:

Table 1. Implementation Samples

Wave file	Size(byte)	Features			
1(bird.wav)	1254528	44770	32909	32445	45112
2(cow.wav)	495424	18148	11213	11963	19192
3(cow2.wav)	279904	11499	6316	6351	10059
4(dog.wav)	737104	28220	16817	16753	28811
5(dolphin.wav)	628704	23706	15046	14906	23626
6(donkey.wav)	1903904	73216	43555	43221	75233
7(duck.wav)	3288576	122618	81543	81334	122826
8(elephant.wav)	360272	14082	8094	7847	14077
9(horse.wav)	248752	8910	6299	6118	8949

The feature array is very sensitive to any changes in the DWF, even if we change one value in the file as shown in Table 2, so this feature array can be used as an identifier or a primary key to retrieve the wave file.

Table 2. RLPB Sensitivity

Wave file	Changes	Features			
1	No change	44770	32909	32445	45112
	Wav(220)=0.0038 changed to 0.5	44772	32906	32446	45112
2	No change	18148	11213	11963	19192
	Wav(220)=-0.0095changed to 0.5	18147	11213	11964	19192
3	No change	11499	6316	6351	10059
	Wav(220)=0.0078 changed to 0.5	11496	6317	6352	10060
4	No change	28220	16817	16753	28811
	Wav(220)=-0.0019 changed to 0.5	28221	16817	16754	28809
5	No change	23706	15046	14906	23626
	Wav(220)=0 changed to 0.5	23708	15045	14906	23625
6	No change	73216	43555	43221	75233
	Wav(220)=0.0056 changed to 0.5	73215	43555	43222	75233
7	No change	122618	81543	81334	122826
	Wav(220)=-0.0075 changed to 0.5	122620	81540	81335	122826
8	No change	14082	8094	7847	14077
	Wav(220)=-0.0210 changed to 0.5	14079	8095	7848	14078
9	No change	8910	6299	6118	8949
	Wav(220)=-0.0156 changed to 0.5	8911	6299	6117	8949

From the results of implementation, we can raise the following facts:

a. Each DWF has a unique features array.
b. FA consists of only 4 elements.
c. FA does not depend on DWF size and has always the size of 32 bytes.
d. FA can be used as a key or a signature to deal with digital wave files.
e. Using 4 element array reduces all the efforts concerning any application that deals with digital wave files.

The proposed RLBP method was implemented several times using various wave files with different sizes, the time to extract features was computed (T2), the same files were treated using CSLBP method and the features extraction time was also computed (T1). The experimental results are shown in Table 3. From Table 3, it can be seen that the speedup of the proposed method is at least 3 times faster, which mean that the proposed method is more efficient compared with CSLBP method

Table 3. Experimental Comparison Results

Wave file size(byte)	CSLBP features extraction time (Sec.) T1	Proposed RLBP features extraction time (Sec.) T2	Speedup
2880000	1.953460	0.589395	3.3143
1903904	0.939946	0.290760	3.2327
1254528	0.418782	0.120215	3.4836
737104	0.338388	0.098481	3.4361
628704	0.100056	0.044843	2.2313
495424	0.030078	0.009357	3.2145
360272	0.030955	0.008587	3.6049
3288576	0.030710	0.008232	3.7306
279904	0.030672	0.007565	4.0545
248752	0.028529	0.006089	4.6853

4. CONCLUSION

A new method of digital wave file feature extraction was proposed, implemented and tested. The proposed method has some advantages comparing with other existing method and it can suit any application dealing with wave files. The extracted features were unique to a wave file and they can be used as an excellent key or signature for a digital wave file.

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